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WASTEWATER MANAGEMENT SUDY FOR CHICAGO-SOUTH END OF LAKE MICHIG--ETC(U)
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(6) # WASTEWATER MANAGEMENT STUDY
FOR

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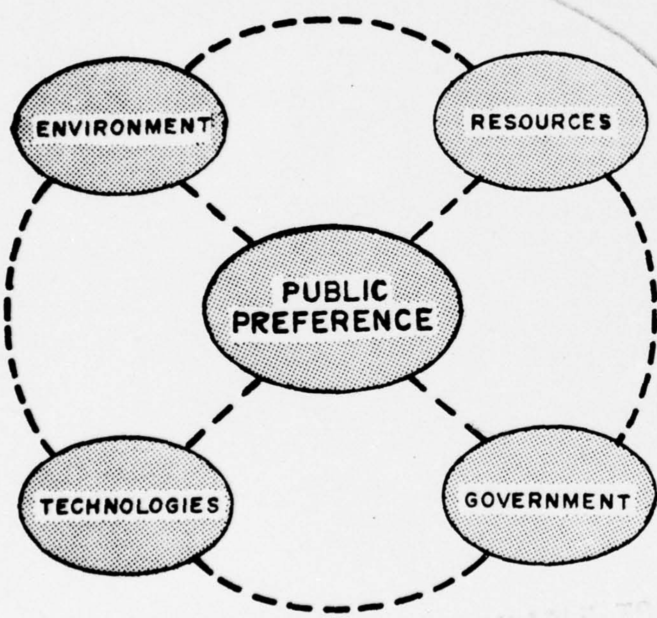
CHICAGO SOUTH END of LAKE MICHIGAN



APPENDIX E.

SOCIAL-ENVIRONMENTAL EVALUATION

410 079

DEPARTMENT OF THE ARMY
CHICAGO DISTRICT CORPS OF ENGINEERS

219 SOUTH DEARBORN STREET
CHICAGO, ILLINOIS 60604

(11) JULY 1973 (12) 84 p.

REPORT COMPOSITION

The survey report is divided into a Summary, and 9 Appendices. A charge for each appendix and summary report to cover the cost of printing will be required, should purchase be desired. The appendices each contain a different category of information. Alphabetically identified, the appendices are:

A. Background Information - This appendix includes the population and industrial projections, wastewater flows and the engineering data used as a basis for planning.

B. Basis of Design and Cost - This appendix contains the criteria and rationale used to design and cost the final alternative wastewater treatment system components.

C. Plan Formulation - The appendix presents the planning concepts and procedures used in developing the alternative wastewater management plans that were examined during the study.

D. Description and Cost of Alternatives - This appendix contains a cost description and construction phasing analysis for each of the final five regional wastewater management alternatives. Components of these alternatives are described in detail in Appendix B.

E. Social - Environmental Evaluation - This report provides an assessment of the social and environmental impacts likely to arise from the implementation of the final five alternatives.

F. Institutional Considerations - This report presents an assessment of the institutional impacts likely to arise from implementation of the final five alternatives.

G. Valuation - This appendix presents a broad evaluation of the implications and use potential inherent in the final five alternatives.

H. Public Involvement/Participation Program - This appendix documents the program used to involve the public in the planning process.

I. Comments - This appendix contains all of the formal comments from local, State and Federal entities as the result of their review of the other appendices and the Summary Report. Also capsulized are the views of citizens presented at public meetings.

The Summary document presents an overview of the entire study.

INTRODUCTION TO APPENDIX E

SOCIAL-ENVIRONMENTAL EVALUATION

The following introduction to Appendix E has been prepared by the Chicago District in order to explain what this appendix accomplishes and how it fits into the entire study report.

SOCIAL-ENVIRONMENTAL APPENDIX - ONE OF THREE EVALUATION APPENDICES

Appendix E is one of three appendices in the C-SELM study report dealing with the evaluation of wastewater management alternatives. This appendix was written for the Chicago District by two groups of academicians who live and work within the study area. The social-environmental evaluation team was selected with two basic thoughts in mind, (1) to have a fair representation of viewpoints from both Illinois (group of professors at Northwestern University) and Indiana (Northwest Indiana Comprehensive Health Planning Council), and (2) to benefit from the ideas of professionals from various academic disciplines (for listing see credit page in Appendix Preface).

DEFINITION OF THE THREE-PART EVALUATION

Appendix E discusses only the social and environmental implications of the regional wastewater management systems, Appendix F describes the impacts of each alternative system on existing institutional arrangements in the area, and Appendix G evaluates the alternatives with respect to the implications from a local, regional and national standpoint. These 3 Appendix E and F were prepared by Contractors for the Chicago District, whereas Appendix G was prepared by District personnel. These three appendices address the final array of ~~five~~ 5 wastewater management alternatives developed in this planning study. Each alternative is unique to itself and represents many advantages and disadvantages depending on the viewpoint of the observer. Alternative I is a reference base reflecting a consolidation of local planning concepts and is designed to meet existing water quality standards established by Illinois and Indiana. The remaining ~~four~~ 4 alternatives ~~(II thru V)~~ employ ~~three~~ 3 distinctly different treatment technologies to achieve water quality levels in keeping with the National goal of eliminating pollutant discharges into navigable waters by 1985 expressed in PL 92-500.

Appendix E evaluations were accomplished by using Alternative I as a reference base and subjectively assessing the effects of the four other alternatives relative to it. The impacts (effects) identified in this appendix are based on social and environmental conditions different

than what we know exist in 1973. In other words, with all five alternatives projected to 2020 conditions, the evaluators analyzed the four No Discharge of Critical Pollutants (NDCP) alternatives in reference to social and environmental conditions which would be expected if the alternative meeting existing effluent discharge standards was in full operation. This usage of a projected reference base has a very real purpose; the study area will be very different in 1990 and 2020 than it is in 1973. Rather than attempt to define what those social-environmental conditions would be like if the reference system was in existence for 50 years, the evaluators emphasized the differences in impacts that may be expected if each NDCP alternative replaced the reference system. These differences were most obvious in terms of the treatment process, number of treatment facilities, and sludge management scheme unique to each alternative system. Since the impacts were often easier to define on a functional component basis, the analysis was structured to point out the strengths and weaknesses of individual parts of the alternatives. By analyzing alternatives on this segmented basis, beneficial attributes were identified and detrimental aspects were highlighted as redesign considerations, or as unavoidable negative characteristics. The Chicago District responded to some of the evaluators redesign suggestions by developing the land treatment prototype discussion in the Annex to Appendix B.

Appendix F provides an estimation of the institutional (i.e. governmental entities) impacts of the C-SELM alternatives and highlights what these impacts would mean to present institutional arrangements for wastewater management. The report compares alternatives to identify differences in impacts expected with each. It serves as a good base of information should any of the alternatives be implemented on the proposed regional base.

Appendix G is a summary valuation discussing the implication of each alternative system ranging from resource consumption, need satisfaction, social-environmental and institutional impacts, and economic costs. Because the impacts extend beyond the C-SELM study area, the implications on the outlying area of influence, the two States, the region and the nation were also discussed. Appendix G contains the disaggregated effect assessments.

INFORMATION UPON WHICH EVALUATION JUDGMENTS WERE BASED

Introduction

Appendix E relies on other appendices for supportive documentation. Engineering specifications, (i.e., those identifying the physical requirements and outputs of each alternative), are of particular importance for the social-environmental effect assessments.

Appendix A provides background data on existing social, environmental and economic characteristics of the C-SELM study area. Appendices B and D contain relevant information on each alternative's design, cost, construction and operation characteristics. These three appendices have been significant information sources for the preparation of all other appendices to the summary report. The following information (summarized here briefly) was provided to the social-environmental evaluation team members.

Alternative Descriptions

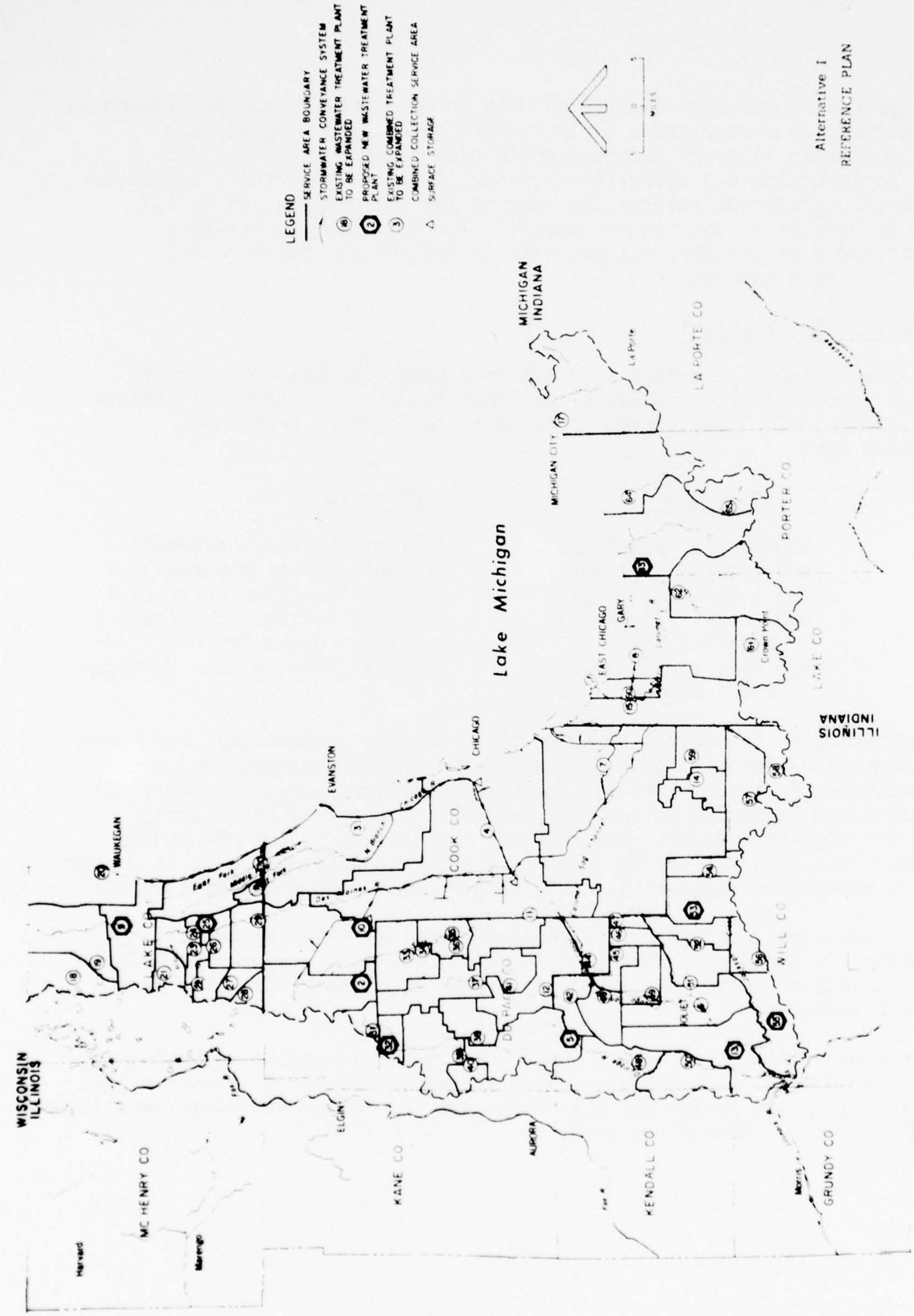
Alternative I, entitled the reference plan, is designed to meet current stream quality standards as identified by the States of Indiana and Illinois. The five treatment criteria designed to meet these standards are:

Type	Performance	Criteria
A	BOD-20mg/1 SS-25mg/1	Illinois Dilution Waters>5:1
B	BOD-10mg/1 SS-12mg/1	Illinois Dilution Waters>1:1
C	BOD-4 mg/1 SS- 5mg/1	Illinois Dilution Waters<1:1
D	BOD-4 mg/1 SS- 5mg/1 NH3-N- 2.5mg/1	Illinois Portion of Chicago & Calumet River Systems
E	BOD-20mg/1 SS-25mg/1 P-80% Removal	Indiana Flows to Lake Michigan

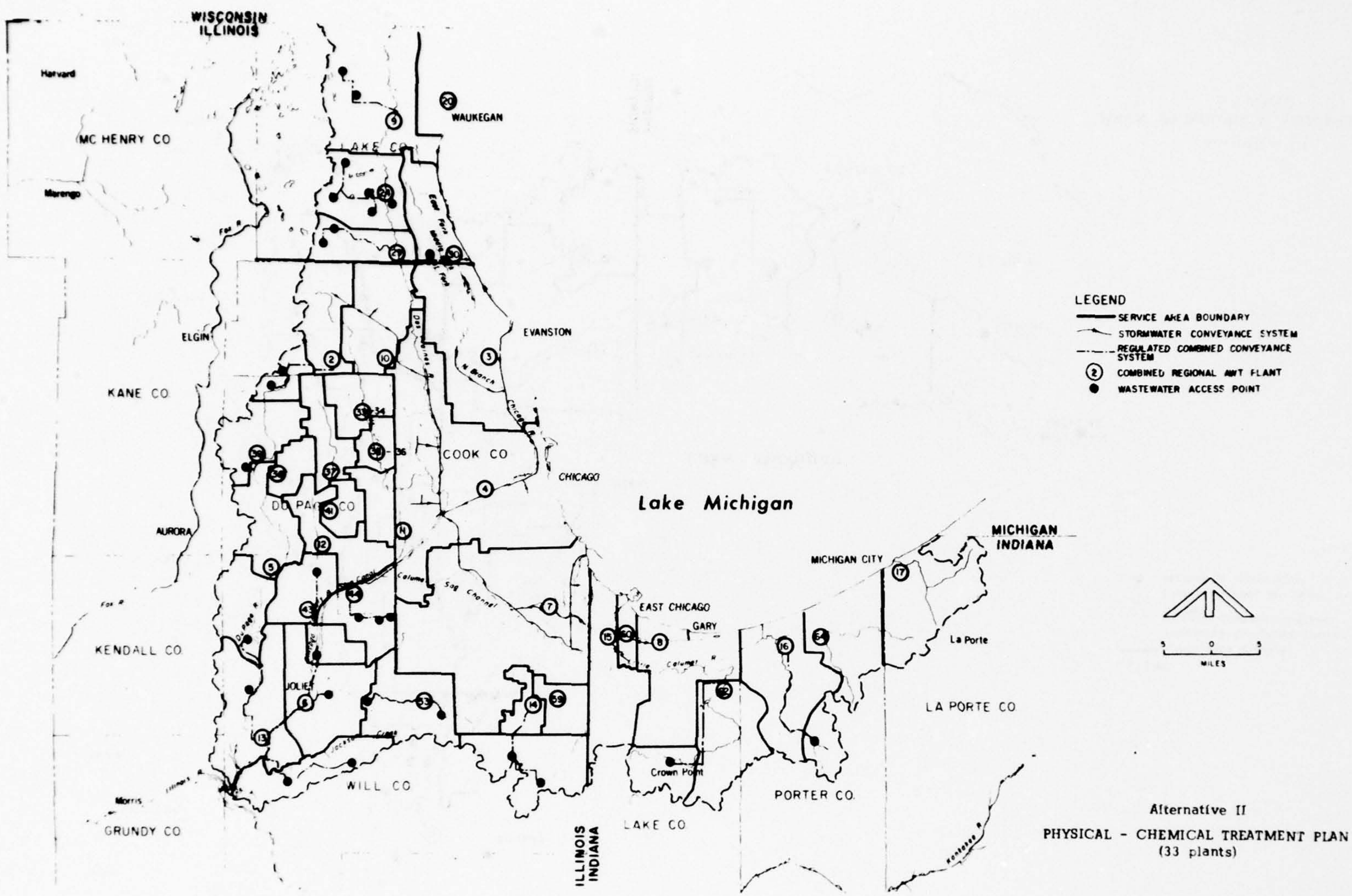
The technologies to achieve these criteria include conventional secondary treatment of wastewater and add-on advanced treatment components, such as: mixed-media filtration, for further biochemical oxygen demand (BOD) reduction and suspended solids (SS) removals; biological nitrification units for ammonia removals; and chemical precipitation, for phosphorus removal. The 64 plant system depicted in Graphic Alternative I, is designed to meet wastewater regional plans of the C-SELM's area planning agencies.

Alternative II utilizes the physical-chemical (PC) treatment technology to conform to the no discharge of critical pollutants (NDCP) water quality standard. As shown in Graphic Alternative II, this is a 33 plant scheme.

For Alternative III, the advanced biological treatment technology is specified to meet the NDCP goal. As depicted in Graphic Alternative III, this is a 17 plant system which incorporates the larger secondary facilities existing in the C-SELM study area.

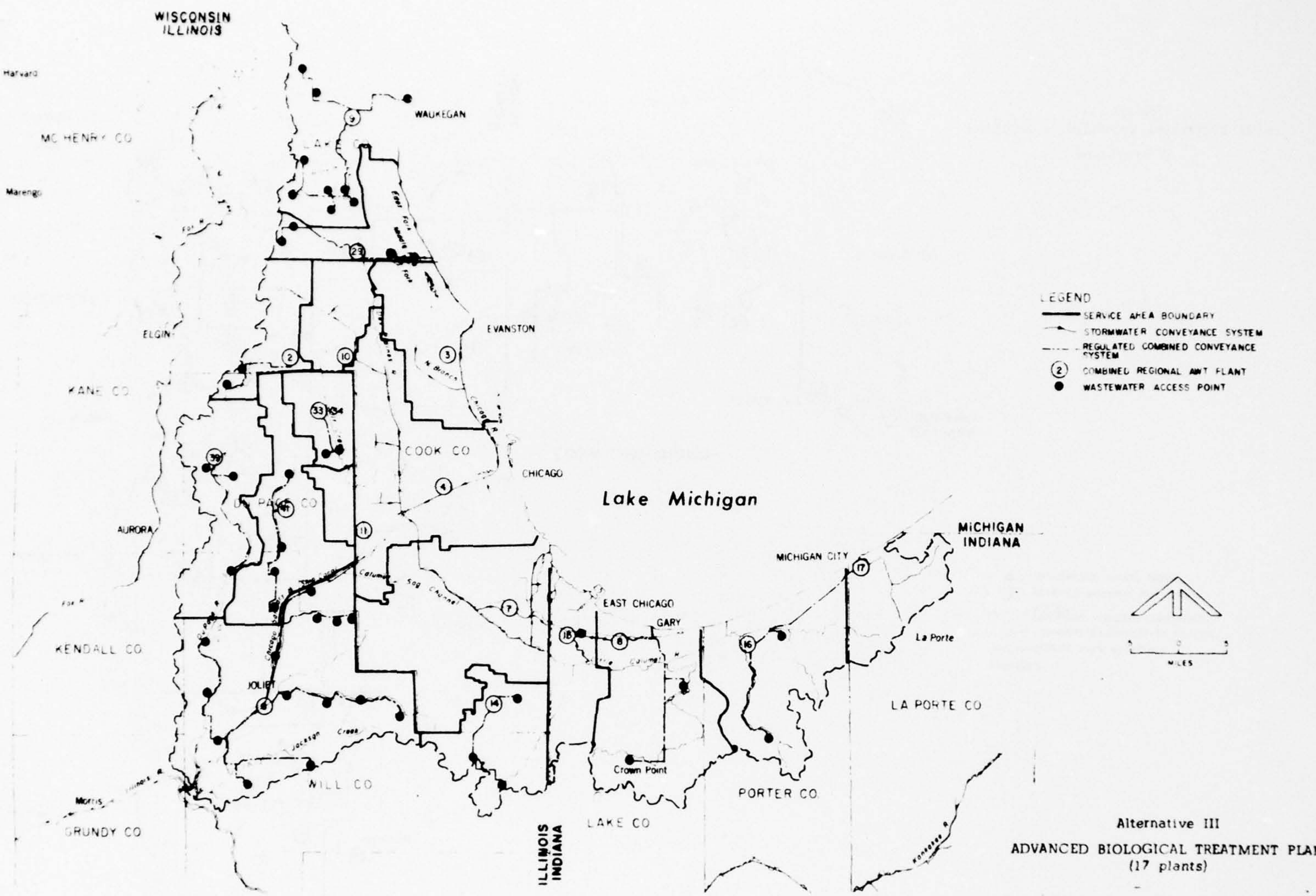


Alternative I
REFERENCE PLAN



Alternative II

PHYSICAL - CHEMICAL TREATMENT PLAN
(33 plants)



Alternative III
ADVANCED BIOLOGICAL TREATMENT PLAN
(17 plants)

Alternative IV utilizes the land treatment technology for the attainment of the NDCP standard. As shown in Graphic Alternative IV this plan consists of 5 major land sites located outside the C-SELM study area. This alternative underwent two basic management concept alterations during the study, (1) the only land purchased are areas where lagoons or sludge disposal facilities are to be located, the remaining irrigation lands to be leased from local farmers thru the use of initial and annual cash payments, and (2) the irrigation system is designed in such a way as to blend into the existing land use, thereby causing minimal disruptions in the rural area.

Alternative V is an advanced biological-land treatment technology combination plan. Graphic Alternative V thus shows the 5 major advanced biological treatment facilities of Alternative III together with 5 smaller land treatment sites servicing the remaining C-SELM area.

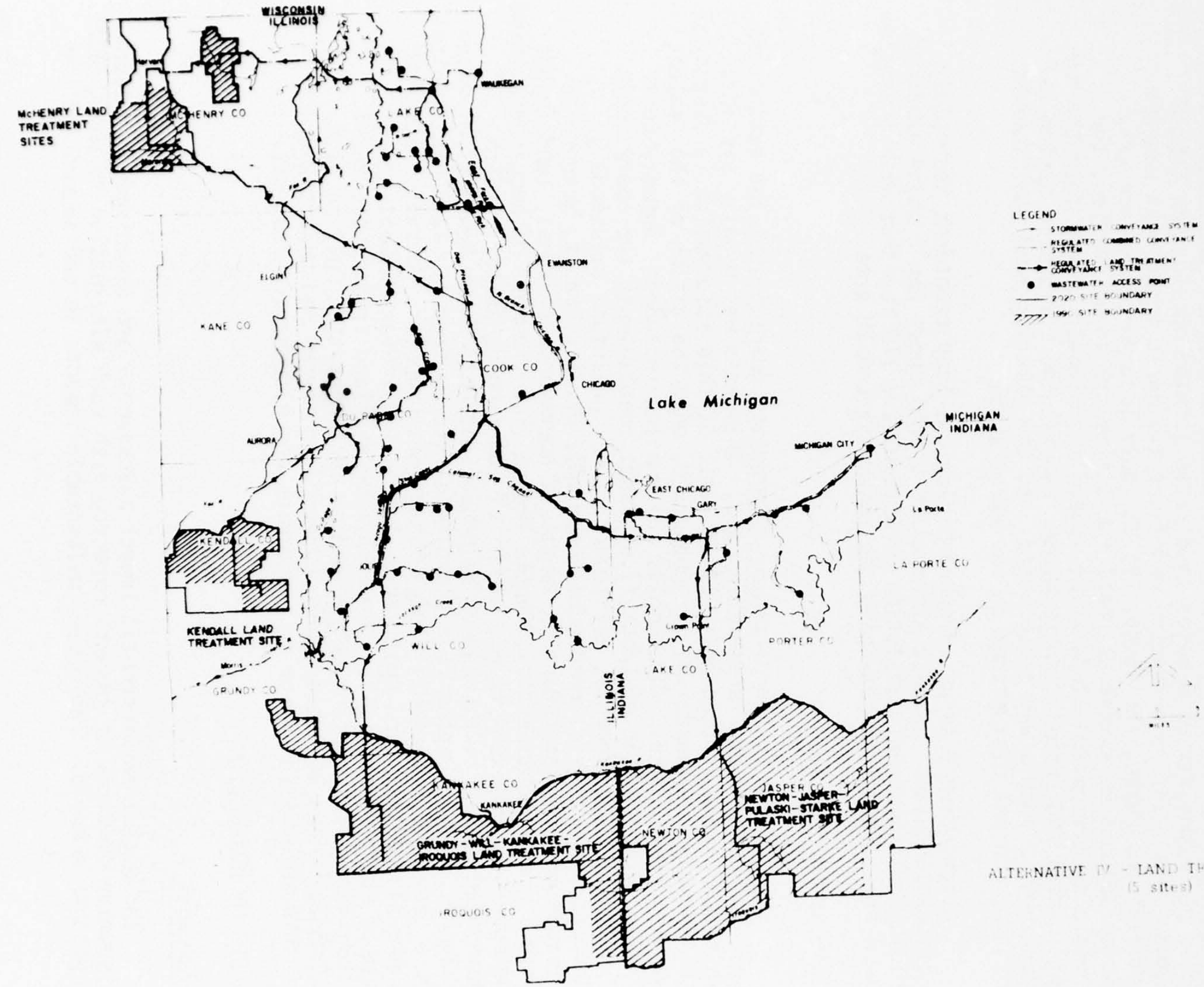
Tabular Information

In addition to the preceding alternative descriptions the evaluators were furnished "hard" scientific data. This data was usually presented in tabular form. Since most, if not all, of this information is displayed in Appendix A, Appendix B, or Appendix G, only the titles of the tables will be listed here. The tabular information included: Summary Cost Tables, Distribution of Labor (i.e. labor requirements for operation), Electricity Requirements, Air Impact (i.e., pollutant emissions), Resource Impact (i.e. resources consumed), Utility Impact, Measure of Disruption (i.e. dependent on length of conveyance systems), Land Impact (i.e., areal requirements), People Impact (i.e., number of people displaced), Measure of complexity (i.e., number of functioning units), C-SELM Abandoned Plants (i.e., caused by consolidation), Water Reuse (i.e. water balance), Stream Depths (i.e., projected stream flows), Flood Plain Relief (i.e. acreage protected), Sludge Management Graphics, Characteristics of Waste Sludges and Land Application Rates, Power Station Cooling and Pumped Storage Costs (i.e., power synergisms-land treatment), Rural Storm Water (description only), and an Implementation Outline (i.e., schedule). The evaluators were expected to review and understand all of this information prior to performing any alternative analysis.

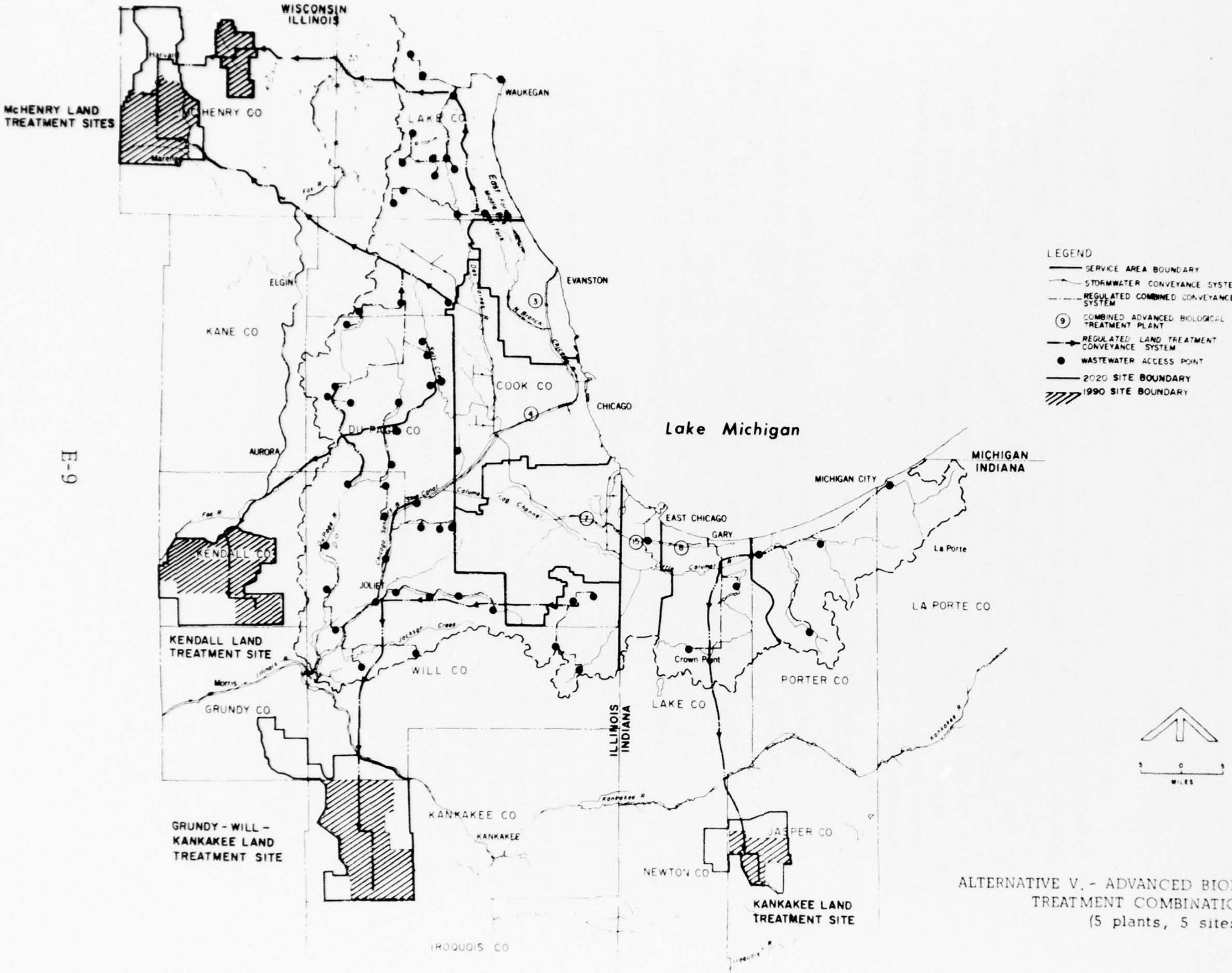
BASIS OF EVALUATION

Framework

The social-environmental impact assessments are organized to present a summary overview of impacts expected with each alternative to the C-SELM region as a whole. Therefore, unfavorable impacts in one segment of the



ALTERNATIVE IV - LAND TREATMENT PLAN
(5 sites)



ALTERNATIVE V. - ADVANCED BIOLOGICAL - LAND TREATMENT COMBINATION PLAN
(5 plants, 5 sites)

region may be counterbalanced by favorable impacts in other segments of the region. The evaluation team was specifically requested by the Chicago District to evaluate the alternatives on a broad community-wide basis because of the value of a regional perspective. The C-SELM region includes not only the areas immediately around Lake Michigan but also areas where treatment, or wastewater conveyance facilities are located, such as land areas used for spray irrigation or sludge disposal. Map 1 is provided to graphically depict the twelve counties adjacent to the study area which are influenced by the C-SELM alternatives.

It was recognized that one of the major factors in the final decision-making process will be the extent to which the area's treatment system will be consolidated or regionalized. Accordingly attention was focused on the system components and the causal effects associated with the function and the alternative's degree of regionalization. Impacts specific to a site and surrounding locality should, of necessity, be evaluated once a wastewater management program is adopted for the study area. At that time an effect assessment and environmental impact statement must be prepared before any phase of the plan of improvement is implemented.

Size and Complexity of C-SELM Area

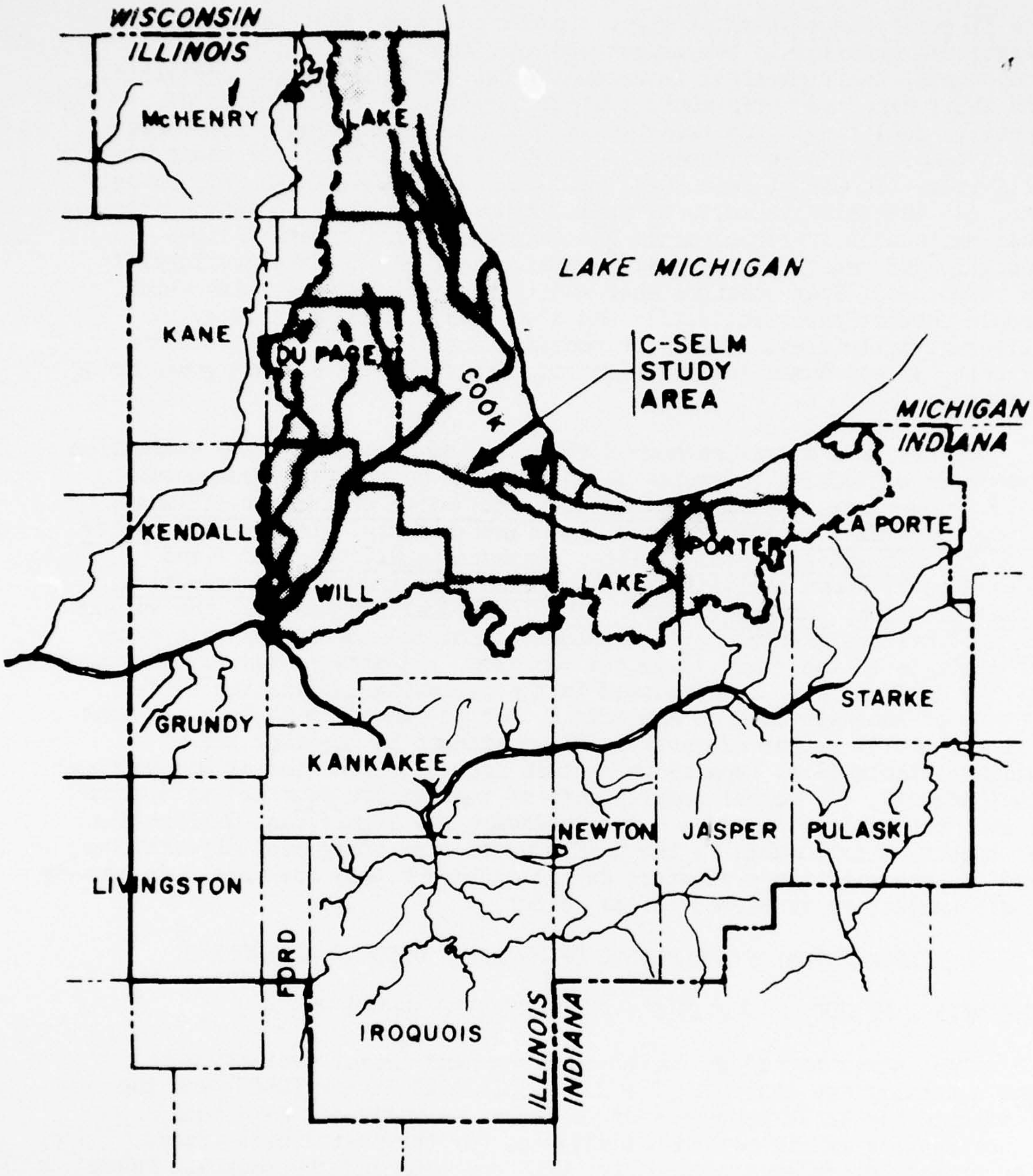
The C-SELM area includes 2,600 square miles around the southern end of Lake Michigan. The C-SELM alternatives exert effects on the twelve other counties adjacent to the immediate study area (Map 1). Approximately 7.1 million people now live in the C-SELM area with a projected increase to 11 million in 2020. Hence, the most critical aspect of the area's size and complexity is the fact that man and his development will change the area regardless of whether a C-SELM alternative is implemented or not.

Difficulty in Long-Range Forecast of Impacts

Any individual has problems in trying to envision what social and environmental conditions will be like in the year 2020. To avoid the complexity of long-range forecasts, the evaluation teams were asked what effect each wastewater management system would have on an already changing environment. This automatically precluded a comparison of alternatives to an undefinable future condition (2020) and underscored the importance of subjectively defining the effects attributable to each system component. Thus the use of a reference alternative becomes even more logical when a 50-year forecast is part of the evaluation.

The Impact Process

Appendix E is based on an analysis of the processes by which alternative wastewater management systems would affect the environment



MAP 1

AREA OF INFLUENCE

and likewise the quality of life. It was concluded that four sets of parameters interact in the impact process, these are: (1) system components, their physical requirements for construction and operation, and their expected performance (output of water, air and solids of specific qualities); (2) those measurable or non-measurable resources which comprise the environmental attributes of the area; (3) those human activities (or use of resources) which make up man's social well-being; and, (4) the relative worth of human values and goals. It was hypothesized that wastewater system elements and characteristics create changes (positive or negative) in environmental conditions and the availability of resources. These changes then modify the effectiveness with which people conduct their activities and also modify the availability of different activities. Then, the modified activities or human states-of-being affect human satisfaction relative to the values and goals being pursued.

By use of a matrix method of analysis, each member of the evaluation team made subjective judgments as to how each major system component (e.g. conveyance, treatment process, distribution of treated effluent, sludge management) affected each major environmental element (e.g. water quality, air quality, soil quality, aesthetic qualities, etc.) and subsequently human activities (e.g. recreation, industrial production, transportation, land use, etc.). The individual judgments of the various disciplines represented by the evaluators can be compared by this type of analysis to the group subjective opinion. Advantages and disadvantages of the analysis will be discussed in the following Explanation of the Method of Analysis Used in Appendix E. It is important to be aware that (1) the matrix method of analysis is an attempt to quantify the unquantifiable (i.e. impacts on certain aspects of our social and physical environment), (2) verbal descriptions of impacts are provided in Section 1 and Section 5 of Appendix E to underscore the significant differences in impacts attributable to the C-SELM wastewater management alternatives, and (3) wherever the evaluators define an impact they are merely expressing their subjective assessment of an effect.

EXPLANATION OF THE METHOD OF ANALYSIS USED IN APPENDIX E

THE MATRIX METHOD OF ANALYSIS - AN INNOVATIVE APPROACH

The matrix method of social-environmental impact evaluation is not a totally new concept. The U.S. Geological Survey (USGS) and the Institute for Water Resources of the Corps of Engineers have been investigating matrix methods of analyses for the past 2 or 3 years. The primary difference between the USGS approach and the approach taken in Appendix E is that analyses in the latter are focused on separate

system components. For example, treatment plants may be smaller in size in one alternative than in another, and therefore create less displacement of people when they are constructed in the same locations. This identification of impact would probably be considered insignificant if it had been lumped together with the rest of the system evaluation. It also enables the designer of the wastewater management system to verify that one aspect of one system is considered better socially and environmentally than another system. Analyses of social-environmental considerations on a system component basis has aided the Chicago District in (1) redesigning specific system components, and (2) screening larger numbers of alternative systems to fewer.

Matrices are used in this appendix as an element of the overall social-environmental evaluation of wastewater management systems. The matrix cannot perform effectively as a method of impact assessment unless it is supported by verbal and graphic displays explaining what is meant by using symbols such as negative (-) or positive (+) numbers to describe impacts. The fact that the matrix method of analysis was used as a tool to bring out the comments appearing in Section 5 should not be ignored. The matrix has enabled the evaluator to give a consolidated group opinion on the impact of a particular system element by placing a (+) or a (-), (connoting whether the impact is considered beneficial or detrimental), and a value from 1 to 3, (connoting degree of impact, from extremely positive to extremely negative). The group opinion is not displayed in a matrix and left unexplained; hence, the importance of Section 5. Supportive sections discuss the matrix method of analysis and what matrices can and cannot do. One particular attribute of the matrix method of analysis is that it can be utilized by multidisciplinary evaluation teams to identify both an individual and consolidated group viewpoint.

HOW MATRICES ARE USED IN THIS APPENDIX

Group Interaction--An Educational Process

1. Prior to Analysis of Alternatives. Written engineering specifications for the five C-SELM alternatives were provided the evaluation team members one week prior to a scheduled group meeting. Each evaluator reviewed the information with particular attention given to identifying that data requiring clarification. Due to both the complexity of the information and the diversity of academic disciplines represented by the evaluation team, many questions were brought out.

2. Group Meeting--Educational Interaction. The group meeting was held for three basic reasons, (1) to insure that each evaluator understood the technical details of the alternatives, (2) to promote group discussions, and (3) to resolve misconceptions.

The evaluators were instructed by the Chicago District to not question the validity of the supplied engineering information; a competent professional engineering firm was responsible for that information. The social-environmental implications of the C-SELM alternatives were the only concerns of the evaluation panel. Therefore, questions were oriented toward understanding the alternatives better. The Chicago District was represented at the meeting to clarify the design aspects of the alternatives.

Group discussions about various alternatives promoted the education of each evaluator. Each individual on the evaluation panel had his own expertise, knowledge, and experience. These discussions, by sharing individual opinions, aided the evaluators in their analysis of the complex wastewater management alternatives. For example, the environmental engineer listened to the sociologist's viewpoints regarding the social implications of engineering designs. The environmental engineer was then better qualified to express a subjective opinion on social effects. Therefore, the fact that the environmental engineer was given equal weight in the numerical analysis of environmental and subsequently social effects was acceptable because of group participation. Individual viewpoints were not lost, since narrative comments were considered necessary to support the matrix analysis.

3. Debriefing Session--After Analyzing Alternatives. The evaluators met to discuss the results of the matrix analysis of alternatives after the individual numerical judgments were averaged by computer. Since these average matrix figures were representative of group subjective opinion, each evaluator was concerned that the analysis was logical and satisfactory. It was the subjective opinion of the evaluation panel that the average numerical estimates of social-environmental effects were both meaningful and satisfactory displays of group judgments. Individual opinions were not lost, due to the narrative comments portion of the analysis - which was extremely important to each evaluator.

Method of Consolidating Various Opinions

Since the evaluation team is composed of many different disciplines, each evaluator usually looks at a system differently. For example: a sociologist may view the land treatment alternatives extremely beneficial overall because they remove a potentially negative impact impetus (i.e. the treatment plant) from a densely populated urban environment to a sparsely populated rural area; an ecologist may view land treatment detrimental overall because of its potential for disruption to existing drainage patterns. The sociologist is asked how significant is the potential disruption to drainage patterns, and he may indicate that it has very

little significance and the system is beneficial overall. When asked for his opinion, the ecologist may place little significance on the sociological value of removing treatment plants from the urban area. Hence, a tradeoff (agreement) in overall system rating is achieved; both the beneficial and detrimental aspects of the system have been identified and the system may be given an overall rating (considering opinions on a whole range of social-environmental parameters) of slightly beneficial. No man is always correct when he expresses an opinion about what may happen (impact) if something else (implementation of a wastewater management system) occurs. The larger and more diversified social-environmental evaluation team can produce a less biased viewpoint of a given alternative treatment system. At the same time, the different disciplines insure that specific good and bad points of each alternative and its components were not overlooked. The evaluation team members realized that the numerical estimate of impact was limited unless explained by narrative comment.

Used as a Tool - Supported by Written Comment

Each evaluator prepared written comments on the specific impacts being considered. Those comments were particularly significant when an evaluator indicated in the matrix format that an impact was extemely beneficial or detrimental. One advantage of the matrix is that the evaluator is sometimes able to let a number signify some unmeasurable concern. The matrices also provided checklists for the benefit of the evaluator so that all possible impacts were considered. Therefore, the impacts which needed emphasis were highlighted in the matrix format by larger positive (+) or negative (-) numbers, and explained by narrative comment (in addition to tabular summaries in Section 5). To quote from the Abstract to Julius Kane's "Intuition, Policy and Mathematical Simulation" paper, "It is argued that the main problem in structuring such impacts for the computer has been one of inappropriate format--intuition and opinion have been treated as garbled arithmetic messages when in fact they are trying to communicate geometric information. With this insight it becomes relatively easy to develop computer languages which can readily combine subjective evaluation with quantitative data."[1] The matrix approach used in Appendix E is based on well standarized psycho-metric scaling procedures. Psycho-metric scaling is a psychological method to express subjective data quantitatively rather than qualitatively.

LIMITATIONS TO THE MATRIX METHOD OF ANALYSIS

The numerical impact ratings given to each system are expressions of subjective judgments based on information provided. Because the judgments

are subjective, the impact ratings are not real value numbers. Therefore, the reader should not draw conclusions pertaining to the relative merits of alternatives or their components on the matrix score alone. Instead, he must delay his conclusion until he has thoroughly analyzed the narrative portions of Appendix E, particularly Sections 1 and 5, and Appendix G. An overview of impacts is provided in Section 1 of Appendix E. Real impact differences between the functional alternative components that can be quantified (such as resources consumed, or air pollutants) are discussed in Section 5.

1 - Paper presented at 1973 International Symposium on Uncertainties in Hydrologic and Water Resource Systems by Julius Kane, Prof. of Math Ecology, Resource Science Center, University of British Columbia.

CHICAGO-SOUTH END LAKE MICHIGAN AREA

WASTEWATER MANAGEMENT STUDY

APPENDIX E

SOCIAL-ENVIRONMENTAL EVALUATION

DEPARTMENT OF THE ARMY
CHICAGO DISTRICT, CORPS OF ENGINEERS
219 SOUTH DEARBORN STREET
CHICAGO, ILLINOIS 60604

CREDITS

These evaluations were made by a team of faculty members and staff drawn from a number of universities located in the C-SELM study area. While all members of the evaluation team are contributing authors of this report, a few have undertaken the responsibility for writing specific chapters of the manuscript. They are:

Editors:	Robert S. Gemmell and Lee C. Strawhun
Section I:	Robert S. Gemmell and Kenneth Cypra
Section II:	George L. Peterson, Joseph L. Schofer and Robert S. Gemmell
Section III:	Robert S. Gemmell
Section IV:	Robert S. Gemmell, George L. Peterson and Joseph L. Schofer
Section V:	A. Sami El-Naggar, Carl H. Krekeler, Mark Reshkin and Lee C. Strawhun
Annex A:	John Maiolo and Kenneth Kehrer
Annex B:	George L. Peterson

The members of the evaluation team (and contributing authors), their special fields of competence, and universities are as follows:

Kenneth Cypra	Water Resources Planning	U. of Illinois, Chicago
A. Sami El-Naggar	Environmental Engineering	Valparaiso U.
Robert S. Gemmell	Water Resources Engineering	Northwestern U.
Edward R. Hermann	Environmental Health Engr.	Northwestern U.
Kenneth Kehrer	Economics	Indiana U. Northwest
George A. Kinias	Environmental Engineering	Valparaiso U.
Carl H. Krekeler	Biology	Valparaiso U.
John Maiolo	Urban Sociology	Indiana U. Northwest
George L. Peterson	Urban Systems Planning	Northwestern U.
Wesley O. Pipes	Aquatic Biology and Chemistry	Northwestern U.
Mark Reshkin	Geology	Indiana U. Northwest
Joseph L. Schofer	Urban Systems Engineering	Northwestern U.
Lee C. Strawhun	Environmental Health Planning	Comprehensive Health
Peter L. Watson	Regional Economics	Northwestern U.

Lee C. Strawhun served as project manager and liason person for the Northwest Indiana Comprehensive Health Planning Council, Inc., and Robert S. Gemmell served in this capacity for the Northwestern group. Computational assistance for the evaluation was provided by Scott Rutherford and Craig Brinkman, both of Northwestern Unviversity.

The impact assessments reported here are the sole responsibility of the evaluators and not the universities or agencies with which they are associated.

The evaluation team acknowledges the helpful cooperation of Lt. Tom Blankenship, Mr. Carl Hessel and Mr. James Maas of the Chicago District Office, Corps of Engineers and Dr. Don Matschke of Bauer Engineering Company.

TABLE OF CONTENTS

PREFACE

BASIS OF EVALUATION

The evaluations of impacts reported in this document were made at the request of the Corps of Engineers on the basis of an early draft of the final specifications for the several wastewater management alternatives proposed for the Chicago-South End of Lake Michigan (C-SELM) Region. The validity of the judgements expressed by the evaluators as to the probable impacts arising from the engineering design of various wastewater management alternatives is, of course, limited by the quality and correctness of information provided to them as a basis for their evaluation. For example, each evaluator was instructed to assume that all descriptions of the performance characteristics of the proposed systems and all estimates of impacts were accurate, although many evaluators questioned the validity of the assumption. To the extent that these descriptions and estimates are in error, the judgements of the evaluators are likely to be incorrect. The same implication holds for the effect of missing information, and absence of detail.

Direct costs attributable to the various wastewater alternatives as proposed in the course of the C-SELM study were not included in the social-environmental impact analysis as performed by our evaluation team, again at the request of the sponsors.

All evaluations were made on the basis of the aggregate impact to the C-SELM region as a whole. As a result, strongly favorable impacts in one area of the region could be offset by strongly negative impacts in another area. Had the available resources (time and money) permitted it, the evaluations would have been greatly strengthened by disaggregating the region into smaller areas and evaluating the impacts on a more localized basis. A similar comment could be made with regard to the level of disaggregation at which the components of the alternatives were considered.

PROTOTYPE INITIATION AND EVALUATION

The evaluation team recognizes that none of the wastewater treatment processes as investigated are new. However, most of the information upon which the various alternatives have been designed, has been extrapolated from small operations or laboratory analysis. It is suggested that if any of the C-SELM alternatives be chosen for implementation that ample provisions be made for full-scale prototype testing and evaluation in the C-SELM area prior to complete initiation of that alternative.

REFERENCE PLAN I

It is important to realize that the most significant goal of wastewater management is the production of effluent that meets effluent quality standards. These standards are specified to protect stream water quality, aquatic life and aesthetic values.

The effluent is also useful because it can provide additional public water supply and enhance recreational and open space availability through storm water control. The effluent quality standards used by the Corps and their consultants for comparison in the Reference Plan, Alternative I do not include the Indiana standards which will be enforced by 1975 and 1976 for plants in the Lake Michigan drainage basin. These Indiana standards together with the well developed Illinois standards, will definitely require the upgrading of the municipal and industrial wastewater treatment plants in the Lake Michigan Region.

It is apparent from our evaluation that the greatest enhancement of water quality in the C-SELM region is attributed to the collection, storage and treatment of the storm water in urban, suburban and rural areas. This will provide for a protection of water quality by preventing sudden inflows of large quantities of pollutants during storms, by providing flow regulation and by improving ground water supplies. Most expected improvements in surface water quality from implementation of Alternatives II, III, IV or V in relation to Alternative I are ascribed mainly to this factor.

Furthermore, it should be noted that the reference plan (64 plants) already provides a high degree of regionalization in comparison with the present array of facilities (130 plants above 1MGD capacity). It is of interest to note that in the August 30, 1972 Interim Evaluation of Impacts Report, the weighted score results showed preference for a higher number of plants in the proposed systems as opposed to lesser number of plants. This reflects the preference by the evaluators for a lesser degree of regionalization than is included in the final treatment plant alternatives (excluding the Reference Plan).

The question was raised among the evaluators as to how highly Alternative I 64 plants with a) the proper effluent standards (which must be achieved by 1975), b) storm water storage and treatment to meet these standards, and c) the degree of regionalization of the system would have rated relative to the NDCP Alternatives. It was felt by several evaluators that many of the goals of wastewater management in the C-SELM area could be achieved at considerably less effort and disruption by implementing such an alternative.

LIST OF TABLES

Continued

LIST OF TABLES

LIST OF FIGURES

SECTION I: SUMMARY OF MAJOR IMPACTS

INTRODUCTION

This report provides an assessment of the social and environmental impacts likely to arise from the implementation of each of the wastewater management alternatives developed for the Chicago-South End of Lake Michigan (C-SELM) region as described in the engineering specifications for the alternatives (Appendix B) and summarized briefly in Section II of this appendix. The report is organized so as to provide, in this initial section, a brief summary of the major impacts ascribable to each of the wastewater management Alternatives II through V relative to those of Alternative I, the reference alternative. In making the assessments, the impacts judged to result from the implementation of Alternative I were arbitrarily set to zero, as a reference base, and the impacts judged to result from implementation of any of Alternatives II through V were evaluated in terms of the departure from the impacts of Alternative I. In other words, would the impacts resulting from Alternative III (for example) be more favorable (positive) or less favorable (negative) than Alternative I? Thus, a relative difference in impact was assessed rather than an absolute change. By this means, the nearly-impossible-to-answer question, "What will the C-SELM region be like (in the years 1990 and 2020) if alternative X is adopted?" was avoided. Instead, the question asked was, "Is the C-SELM region likely to be better (in terms of social and environmental impacts) if alternative X is implemented rather than alternative I?"

The choice of Alternative I as the reference base (rather than present conditions, for example) was made by the Corps of Engineers to give recognition to the probable future developments in wastewater management in the C-SELM region that would result with current wastewater planning for the region.

Subsequent sections of the appendix describe the methodology used for impact assessment (Section II) and present the resulting assessments of impact in greater detail: impacts are identified in terms of a set of primary impact dimensions, largely environmental (Section III), and then in terms of the human activities affected (Section IV). The report concludes with an extended verbal description of the impacts (Section V) quantified numerically in the previous sections. Two annexes to the report are provided: the first (Annex A) describes the method used to translate the primary impacts into human impacts; the second (Annex B) describes and analyzes the diversity of viewpoints characterizing the composition and concerns of the individual members of the evaluation panel.

In summarizing the major impacts for each of the alternatives, a conscious effort was made to provide overview rather than depth, and to treat each alternative as an entity insofar as that was possible. In later sections of this report, the impacts are presented and discussed in terms of a set of six functional components of which the alternatives are composed. The six functional components are described in Section II. This approach permitted a more detailed development of the impact assessments and a closer identification of the components producing the impacts.

In this summary, the impacts judged to result from the implementation of each wastewater management alternative are discussed in terms of three major factors: Environmental Quality, Social Well-Being, and Economic Development. Several sub-topics are embodied within these factors as follows:

A. Environmental Quality

1. Health, diversity and productivity of plants and animals
2. Preservation or enhancement of land and water resources

B. Social Well-Being

1. Hygienic characteristics
2. Aesthetic characteristics
3. Social characteristics

C. Economic Development (regional base)

All impact evaluations were made on the basis of the aggregate impact (in the particular dimensions being considered) to the C-SELM region as a whole. As a consequence, a localized unfavorable (negative) impact in one area of the region might be counterbalanced by a favorable (positive) impact in another area of the region. The result could be a neutral impact for the region as a whole.

For evaluation purposes, the C-SELM region was defined to include not only those areas around Lake Michigan comprising the basic region, but also any areas outside the basic region where treatment facilities, pipelines, or conduits were located (such as the land areas used for wastewater treatment, sludge disposal, etc.).

Discussion for each of the five C-SELM alternatives is divided into several topics: A <u>Description</u> provides a concise identification of the alternative in question. <u>Overview of Impacts</u> attempts to briefly portray the overall impact of the alternative in question to the remaining alternatives. Following this are three topics, each addressed to one of the three major impact factors mentioned above.

ALTERNATIVE I

DESCRIPTION

Wastewater management Alternative I is comprised of 64 biological treatment plants of substantially conventional design. The effluent from these plants will meet current water quality standards for Illinois and Indiana. At some plants, conventional secondary biological treatment is augmented by filtration of part or all of the effluent to meet requirements for suspended solids discharge. Biological nitrification for ammonia reduction is used at those plants discharging to the Chicago and Calumet River system, and phosphorous removal is employed for those plants whose effluent reaches Lake Michigan. The only storm water treated in this alternative includes the combined several areas of the Chicago Metropolitan area (following the Chicago tunnel plan) together with the cities of Gary and Hammond. As such, it offers some improvement in the management of storm water quality over current practice. Sludge management is accomplished by a combination of land reclamation and agricultural utilization, with the latter predominating.

This alternative represents a substantial consolidation of existing treatment facilities (a reduction from about 135 plants above 1MGD now in existence to 64 plants proposed for the alternative). Most of the plants to be eliminated are very small. The alternative represents an estimate of the trend for wastewater management in the region. As such, it served as the reference alternative for the evaluation of impacts of all other alternatives (II through V) for wastewater management in the region.

OVERVIEW OF IMPACTS

The detailed assessments of impacts judged to result from the implementation of Alternatives II through V were made in terms of the impacts of these alternatives relative to those anticipated from Alternative I.

As a consequence of the evaluation strategy employed, no detailed assessment was made of the impacts to be expected from the implementation of Alternative I. Some of the evaluators viewed it to be "one of the best" from an overall standpoint of impact while many regarded it as among the worst. In the following section, an attempt is made to speculate about the impacts that would be produced by implementation of Alternative I as compared to the present situation for wastewater management and the conditions produced thereby throughout the C-SELM region.

ENVIRONMENTAL QUALITY

Health, Diversity and Productivity of Plants and Animals.

A slightly favorable impact on biotic communities is anticipated as a result of improving surface water quality and reducing the frequency of combined sewer overflows. The reduction of treatment plants from 135 to 64 will require construction of more extensive conveyance systems, and so unique and rare species and things are more susceptible to disruption. This potential impact is considered unfavorable. The overall impact on ecosystem status will be neutral or very slightly positive since the impact of continued nutrient discharges to surface streams (expected with existing standards) is difficult to assess.

Preservation or Enhancement of Land, Air and Water Resources.

Surface water quality is judged to improve moderately because of the increased efficiency and reliability of wastewater treatment (due to the elimination of the very small packaged treatment plants). The treatment of storm water in the combined sewered areas will contribute strongly to this improvement. Effects on surface water quantity, however, are likely to be unfavorable due in part to the elimination of the small treatment plants located on small streams. In times of drought, the effluent from these plants often provides the only flow in the stream. Consolidation of treatment plants also leads to excessively high flows (in excess of estimated channel capacity) in some streams at the point of discharge of treated wastewater into those streams, again a negative impact because of flooding unless such discharges are prevented.

Groundwater quality and quantity are not likely to be affected by the implementation of Alternative I. Air quality should improve slightly with the relocation of most sludge treatment to land reclamation or agricultural areas, but the impact change is more one of relocation than of absolute reduction. The net impact on mineral resources should be neutral (no change) as a result of internal compensations (more efficient use of construction material in construction of treatment plants as compared with the additional resources consumed in constructing pipelines).

A slightly favorable impact on soil quality is anticipated to result from the greater utilization of sludges for agriculture and land reclamation.

SOCIAL WELL BEING

Hygienic

Health, safety and general hygienic conditions are expected to improve somewhat as a consequence of the general improvements in environ-

mental quality previously discussed. The major contributory factor is the improvement in surface water quality.

Aesthetic

The only change in aesthetic characteristics that can be anticipated by the implementation of Alternative I is the improvement in surface water quality resulting from increased efficiency and reliability of treatment plants and the effect of storm water treatment in the combined sewered areas. This improvement is partly offset by the probable drying up of small streams in drought times when the small treatment plants discharging to those streams are eliminated. A flowing stream with fair-to-poor quality water is generally preferred aesthetically to a dry stream bed.

Sensory quality of the environment should improve moderately with the improvement in stream water quality and the relocation of sludge disposal to agricultural or land reclamation areas. The use of sludge for land reclamation purposes produce especially favorable impacts on aesthetics. However, the amount of land reclaimed via Alternative I is not considered significant.

Social Characteristics

The social characteristics of the C-SELM region are not expected to be appreciably affected by the implementation of Alternative I. Residential activity and recreation may be slightly enhanced because of the modest improvements in surface water quality and sensory quality of the environment, but this may be offset by the slightly negative impacts resulting from increases in immigration and population density afforded by the implementation of a regional wastewater management system(i.e. construction of housing developments and related facilities would become more feasible).

ECONOMIC DEVELOPMENT

Commercial and industrial land use is likely to be somewhat negatively affected necause of the consolidation of small treatment facilities into larger plants. This effect is due to the fact that larger treatment plants occupy more space, which is usually within commercial-industrial areas. Agricultural land use should be enhanced (a favorable impact) as a result of the sludge disposal techniques. The overall impact on energy is judged to be neutral, since the electrical energy used is of about the same magnitude as the electrical energy equivalent of the excess natural gas produced by the heated aerobic sludge digestors.

Commercial and industrial production, private service, employment and income are not judged to be affected by the implementation of Alternative I.

Food production should be enhanced slightly by the application of sludge to agricultural land. Public service will also be increased (a positive impact) by the existence of a regional wastewater management system. Public finance, overall, should not be affected since the cost of the regional system is not likely to exceed (and may well be less than) the cost of continued private investment in numerous small wastewater management facilities.

Construction services would benefit slightly, if at all, from the implementation of Alternative I, again because of the compensating effects of public investment in construction of wastewater treatment facilities supplanting private investment.

IMPACTS COMMON TO THE NDCP ALTERNATIVES

Some functional components for wastewater management are common to Alternative II through V, the "No Discharge of Critical Pollutants" (NDCP) alternatives. As a consequence, the impacts of these components are also common to all NDCP alternatives as well. Before presenting the impacts of each alternative in turn, the most noteworthy of the impacts common to the NDCP alternatives will be discussed. These impacts will also be included, but not discussed further, in the summary of impacts for each alternative.

POTABLE WATER SUPPLY

The basic premise for all of the alternatives was that future potable water supply needs would be met by continued withdrawals from Lake Michigan and from the available ground water resources. This would require, after about 1990, that the Illinois requirements for Lake Michigan water exceed the currently authorized 2068 million gallons (e.g. 3200 cfs) per day diversion. By the year 2020, almost 1360 million gallons a day of Lake Michigan water beyond the authorized amount would be needed. An option was provided for the NDCP alternatives (II through V) to engage in a limited reuse of treated stormwater and reclaimed municipal and industrial wastewater, so as to maintain the diversion from Lake Michigan at its authorized level. The noteworthy impacts judged to result from the practice of reuse follow.

Environmental Quality

The only appreciable impact on Health, Diversity and Productivity of Plants and Animals was a slight reinforcement of the ecosystem status (by insuring little alteration from existing conditions). More positive impacts accrue to the Preservation or Enhancement of Land, Air and Water Resources in terms of surface and ground water quantity as a result of the smaller quantities of water diverted from Lake Michigan into the C-SELM region.

Social Well Being

Hygienic characteristics of the region were judged to be minimally degraded by the potable reuse of reclaimed wastewater, due to the somewhat poorer quality of the reclaimed water relative to that of Lake Michigan.* Aesthetic characteristics were also judged to be diminished somewhat for the same reasons. Social characteristics were judged not to be affected noticeably, however, an effective public education program will be necessary before recycled water will be acceptable for potable supply.

Economic Development

Since the same volume of water would be available via reuse of reclaimed water or from Lake Michigan, there should be no differentiation between them in terms of economic development.

STORM WATER MANAGEMENT AND EFFLUENT DISTRIBUTION

Alternatives II through V all provide for the collection, storage and treatment of large quantities of storm water runoff from all urban suburban and rural areas. The rural storm water management system consists of local collection and storage of runoff in small ponds widely distributed throughout the region, and treatment by a spray-irrigation technique on land adjacent to the ponds. Underdrains or wells collect the treated storm water so that it can be reused for potable supply or redistribution to local streams.

Urban and suburban storm water management also utilizes storage facilities but relies on the treatment plant system peculiar to each alternative for treatment of storm runoff.

The fact that vast quantities of storm water runoff are collected and treated requires that the treated storm and wastewaters be redistributed to the streams throughout the area. While the quantities distributed to each stream and location are not identical for all alternatives, the range of variation is limited and the variation was not judged to produce significantly different impacts accruing to any alternative as a result of the variation. As a general rule, however, the larger the number of treatment sites, the more uniformly is the effluent distribution throughout the region and the less complex is the piping system needed to convey the storm water from its treatment site for redistribution of the treated effluent back to the streams.

The following impacts associated with storm water management and effluent distribution are common to Alternatives II through V.

Environmental Quality

The health, diversity and productivity of plants and animals are substantially enhanced by the improved surface water quality and by the reduction in frequency of flood and drought flows in the streams. Unique and rare things may be affected slightly negatively, however,

*Reclaimed wastewater has higher TDS (total dissolved solids) concentrations than Lake Michigan water.

because of the possibility that the natural flows through bogs and swamps may be reduced by the rural storm water management system.

Land and water resources will be substantially enhanced by the improvements in surface water quality and quantity. Ground water quality and quantity are not judged to be affected appreciably. The frequency and extent of flooding will be substantially reduced as a result of the system's capacity for regulation, and redistribution of storm water. This, in turn, permits the flood plain to be utilized more fully and beneficially for recreation and open space purposes. Commercial, industrial and residential development on the flood plain should still be discouraged, however.

The rural storm water management ponds offer potential recreational and open space uses, as do the adjacent irrigation areas. The impact on mineral resources will be slightly negative because of the construction materials utilized in the conveyance and treatment systems. No appreciable impact is foreseen on soil quality.

Social Well Being

Hygienic characteristics of the region were judged to be greatly enhanced by the collection and treatment of storm water. The health and safety of the region's inhabitants will be vastly improved by both the improved surface water quality and the reduced incidence of flooding.

The aesthetic characteristics again reflect the improvements in surface water quality and the attendant improvements in sensory quality of the environment. Recreation and open space also benefit greatly from the reduced incidence of floods and droughts, the higher ave-erage stream flows, and the more beneficial utilization (i.e., recreational) of the flood plain. In addition to the recreation and open space benefits previously described, residential land use and residential activity near rural storm water management ponds and for flood plains were judged to be significantly enhanced.

Economic Development

The overall impact on economic development was assessed to be slightly to moderately negative. Energy requirements are substantial in order to transport the vast quantities of water to and from the treatment facilities, as well as to treat the water itself. Commercial, industrial and agricultural land uses were judged to be encroached upon (a negative impact) to provide the necessary land for storage and treatment facilities. As a result, the impacts on commercial and industrial production are also slightly negative.

ALTERNATIVE II

DESCRIPTION

Alternative II constitutes the physical-chemical (PC) treatment

alternative. Included are 33 treatment facilities, urban-suburban-rural components of stormwater management and sludge management through agricultural application. An option exists in the development of potable water supply for the C-SELM region; either with emphasis on Lake Michigan as a supply source or alternatively the reuse of treated wastewater for a significant portion of potable supply needs.

OVERVIEW OF IMPACTS

Of all the alternatives (including the reference) this alternative will produce the largest number of negative impacts, in terms of environmental dimensions and human activities. As a result, this alternative was rated least desirable of all.

ENVIRONMENTAL QUALITY

Health, Diversity and Productivity of Plants and Animals

The overall impact on biotic communities is judged to be slightly to moderately negative. Air pollutants and emissions from the treatment process, and the PC sludge management requirement for excessively large tracts of land are considered significant negative design factors. Aquatic communities in C-SELM streams would be somewhat enhanced by the improvements in surface water quality. Unique and rare environmental elements are also negatively affected, largely as a result of the potential for disruption caused by the construction of conveyance systems for the water and sludge. Air pollution from the treatment processes may contribute to this assessment as well.

Preservation of Land, Air and Water Resources

The common elements of storm water management, NDCP effluent standards and effluent distribution combine to produce positive impacts on surface water quality and quantity and, to a lesser extent, on ground water quality and quantity. No impact is perceived on soil quality, aside from the effect of PC sludge (similar to lime), but strong negative impacts are recorded for air quality and mineral resources. Both of these are predominantly associated with the PC treatment process. Most air pollution originates in line recalcination by incineration, which releases vast quantities of nitrogen oxides and sulfur oxides as well as particulates. The negative impact on mineral resources arises from the consumption of clinoptilolite and other minerals used in the treatment process (see Table E-V-3).

SOCIAL WELL BEING

Hygienic

The water quality impacts common to all NDCP plants provide strongly favorable impacts on surface and ground water quality. A strongly negative impact on air quality was judged to result from the

implementation of the PC wastewater management alternative. Of particular concern from a hygienic standpoint are the oxides of nitrogen and sulfur that are emitted in large quantities. Although the evaluators were informed that the air pollution emissions would meet current standards, the quantities of air pollutants emitted with the PC alternative may be 10 times as great (or more) than the quantities emitted with the other alternatives. In a metropolitan area such as C-SELM, air pollutants are emitted from a variety of sources. Few of these sources have the option of reducing their emissions by adopting different technology. The selection of a PC wastewater management alternative for implementation would have to be justified on exceptionally strong grounds to overcome the adverse effects of air pollution (see Table E-V-2).

The overall impact on health and safety ascribed to Alternative II was slightly negative.

Aesthetic

The overall impact of Alternative II on the aesthetic characteristics of the C-SELM region was judged to be slightly positive (but other NDCP alternatives were 3 to 5 times more strongly positive). The net positive impact stems mostly from the water quality and quantity impacts described previously and from open space impacts of the storm water management and agricultural disposal of sludge. These positive impacts are partly counterbalanced by the strongly negative impacts on air quality and the weakly negative impacts on sensory quality (noise, odors, visual, irritants, etc.) of the environment.

Social

The overall impact of Alternative II on Social Characteristics was judged to be neutral relative to that of Alternative I. This represents a balance between a moderately positive impact associated with recreation and an accumulation of small negative impacts associated with residential land use and activity, access, immigration, cultural-educational activity, population density and community social and political structure. These small negative impacts all accrue as a result of the effects described previously under the topics of environmental quality and social well being.

ECONOMIC DEVELOPMENT

The aggregate impact on economic development judged to result from the implementation of Alternative II was moderately negative. Heading the list of strong negative impacts was the excessive drain on energy resources, especially natural or synthetic gas. The requirement for 160 to 190 billion BTU per day is two to three times the amount required for Alternatives III and V. Alternatives I and IV have no

requirements for natural gas. The demand for electrical energy, about twice that required for the reference alternative, is less than the other NDCP alternatives. However, the demand for electrical energy is only about 20% of the total energy requirement for this alternative.

The negative impacts described previously under the topics of Environmental Quality and Social Well Being combine with the energy impact to produce small to moderate negative impacts in all aspects of economic development. These aspects, listed in decreasing order of severity of impact are: industrial production, commercial production construction services, employment, income, public finance, private service, public service. If only one major industry were precluded from locating in the C-SELM region because of the excessive demands placed on the region's energy, air and land resources by the PC treatment alternative, the economic impacts would ripple through the region in much the same way and magnitude as are attributed to this alternative.

ALTERNATIVE III

DESCRIPTION

This management system is composed of 17 advanced biological treatment plants plus a storm water management system for urban, suburban and rural areas similar to that used in all other NDCP alternatives. Sludge management is by either of two options: application of sludge to agricultural lands as a fertilizer and soil conditioner; or application to strip-mined or related areas as a reclamation measure. Future needs for potable water may be met either by a combination of ground water and Lake Michigan water or by some reuse of reclaimed wastewater.

OVERVIEW OF IMPACTS

The impacts assessed for this alternative are consistently among the most favorable of all the alternatives considered. When land reclamation is used as the method of sludge management, the alternative produces the highest impact ranking of all alternatives that do not employ a power synergism. Optimal variations of the alternatives are the second and fourth highest ranked of all the alternatives and variations, and are slightly exceeded only by the somewhat similar alternative V (5 AB plants plus dispersed land) for which a power synergism is employed.

ENVIRONMENTAL QUALITY

Health, Diversity and Productivity of Plants and Animals

Little impact in this area is anticipated to result from the

implementation of this alternative in any of its optional forms. The aggregate effect is a modest reinforcement of the present ecosystem status, especially when land reclamation (the application of sludge to strip-mined areas to rebuild the topsoil) is utilized as the means for sludge management.

Preservation of Air, Land, and Water Resources

The impacts on physical resources (air, land, and water) resulting from Alternative III are substantially more favorable in this category than would result with Alternative I. The favorable impacts common to the NDCP alternatives as a result of the management of storm water runoff, in concert with the higher water quality standards inherent in no discharge of critical pollutants, produced substantial improvements in surface and groundwater quality and in the spatial and temporal distribution of water resources throughout the C-SELM region. Overall, soil quality of the region was considered to be about equally enhanced by either of the sludge management methods although obviously land reclamation produces large impacts in small areas while agricultural utilization produces small impacts over large areas. Air quality was not considered to be degraded to a significant extent, although some pollutants would be emitted. The alternative did produce some drain on mineral resources through the construction of the large facilities, but these were partly compensated by the positive impact on mineral resources due to the utilization (recycling) of sludge.

SOCIAL WELL-BEING

Hygienic Characteristics

The anticipated improvements in surface and ground water quality resulted in a generally positive impact on the hygienic characteristics of the region. This may be attributed more to the suitability of the surface waters for recreational uses such as swimming, fishing and other uses, than to the use of the waters for potable needs, since further treatment of the waters to produce potable quality is anticipated in all instances.

Aesthetic Characteristics

Alternative III offers a potentially greater improvement in the sensory quality of the environment (visual appearance, odors, noise, etc.) than any of the other treatment alternatives when land reclamation is the method for sludge management. The opportunity for conversion of blighted strip-mined and related low productivity lands into useful and pleasing areas has a dominating effect here, although the improved visual appearance of surface waters and the elimination of malodors from ponds and streams common to all the NDCP alternatives contribute further to the favorable aesthetic characteristics.

Social Characteristics

Alternative III was judged to have strong favorable impacts on recreation and open space, although less than with some of the options within the land treatment alternatives. This favorable impact was also more strongly displayed when land-reclamation was utilized for sludge. A similar but smaller positive impact was found in the dimension of residential land use, due to the physical suitability of reclaimed areas for attractive residential areas. Small negative impacts on access were anticipated during the construction of pipelines, tunnels and other facilities.

In general, the alternative was considered to provide substantial improvements in the social characteristics of the area overall. Recreation and residential activity are most favorably affected. These positive impacts results from the favorable impacts on environmental quality and other social characteristics described previously.

ECONOMIC DEVELOPMENT

All alternatives reflect a negative impact on economic development, but least so for Alternative III as a whole. Energy consumption is a substantial component of this negative impact. Both natural gas and electrical energy are required in substantial quantities. Industrial production is also somewhat negatively affected by Alternative III, partly as a result of the large treatment facilities required and located most commonly in industrial areas, precluding the use of the land for industrial purposes. The competition between industry and wastewater management for the use of the region's air and energy resources also influences this. Commercial production somewhat shares in this negative impact for similar reasons. Other dimensions of economic development--food production, construction services, public service, private service, employment, income and public finance--are only slightly affected by the alternative.

ALTERNATIVE IV

DESCRIPTION

Alternative IV constitutes a totally land treatment process. Included are several land treatment sites dispersed about the fringe of the C-SELM study area. Wastewater is to be conveyed to the land sites and returned for reuse in the urban portion of the C-SELM area. Sludge management contains two options: to manage sludge for agricultural purposes as an integral part of the land treatment facility or to utilize sludge elsewhere for reclamation of strip-mined land. The siting of power generation facilities within the land treatment sites utilizing the storage lagoons as cooling ponds is also an option. Furthermore, the procurement of potable water supply from Lake Michigan or from treated wastewater serves as an additional option.

ENVIRONMENTAL QUALITY

Health, Diversity and Productivity of Plants and Animals

Implementation of this alternative was viewed to produce a significantly negative impact on biotic communities and on unique or rare things, primarily because of unavoidable disruption to these things during construction or installation of the land treatment facilities. Ecosystem status is moderately enhanced, however, by the preservation of open space inherent in the land treatment alternative.

Preservation or Enhancement of Land, Air and Water Resources

The favorable impacts on water quality and quantity and open space common to all NDCP alternatives are clearly in evidence here. They are further enhanced by the absence of air pollutant emissions and depletions of mineral resources for treatment processes. Indeed, a net positive impact on mineral resources is anticipated in recognition of the potential value of the construction materials (rock and unconsolidated materials) recovered from the mining of the wastewater conveyance tunnels. Soil quality is also moderately enhanced, more through the sludge management options than by irrigating croplands with wastewater.

The region's open space lands are definitely preserved (a positive impact) by the implementation of this land treatment alternative.

SOCIAL WELL-BEING

Hygienic

The generally favorable impacts described earlier as attributable to all NDCP alternatives are diminished somewhat by the unfavorable impacts in this category attributable to the spray-irrigation of partially treated wastewater and the presence of large storage and treatment lagoons. Health precautions will be designed into the land treatment systems. However, the fact that precautions are necessary is viewed as a negative impact.

Aesthetics

Here again the generally favorable impacts attributable to all of the NDCP alternatives in terms of environmental quality serve to promote the aesthetic characteristics attributable to this alternative. These positive impacts are reinforced by the favorable impacts on sensory quality of the environment since open space is afforded by the implementation of a land treatment alternative.

Social Characteristics

Moderate negative impacts on residential land use (since the land would be restricted to agricultural use) and on access resulting from the reservation of large tracts of land for wastewater treatment and agriculture are offset by the strongly positive impacts on recreation and open space attributable to the alternative. When sludge management by land reclamation is employed, small positive impacts accrue to the social characteristics of residential activity, immigration, cultural-educational activity, and community social and political structure. These impacts result largely from the recognition of potential benefits that are anticipated for the use of the reclaimed land area. When sludge management is by agricultural utilization, however, the positive impacts on social characteristics disappear and the alternative is basically neutral relative to Alternative I.

ECONOMIC DEVELOPMENT

As with all of the NDCP alternatives, a major negative impact on economic development arises in terms of the energy requirements for the operation of the treatment processes. These demands are wholly for electrical energy, though, and when power plants are sited on the land treatment facilities, the aggregate impact is regarded as slightly less severe. Commercial, industrial and agricultural land uses are subject to slightly-to-moderately negative impacts when power plants are not sited on the land treatment areas. The assumption was made that the total amount of power generated in the C-SELM region would be the same regardless of the location of the power generating facilities. Since large areas are required for the land treatment facilities and processes, the failure to site power facilities on the same land as the treatment facilities must mean that the power plants would be sited in commercial, industrial or other agricultural land use areas in competition with those uses for the space.

In the aggregate, the impacts on economic development attributable to this alternative are slightly-to-moderately negative. Most affected are commercial and industrial production as is true of all the NDCP alternatives. The remaining dimensions of impact (employment, income, public and private service, public finance) can be viewed as spill-over effects from the impacts on commercial and industrial production. The negative impacts are less severe when power plants are sited on the land treatment areas, reflecting the potential competition for power and land use between commerce and industry on the one hand and wastewater treatment facilities and power generation stations in the other hand.

ALTERNATIVE V

DESCRIPTION

A close relative of alternative III, this alternative utilizes 5 advanced biological treatment plants to serve the urban and inner suburban area (about 70% of the total wastewater flow) in combination with land treatment processes serving the outer suburban area at 6 sites dispersed throughout the region. Sludge management is by land reclamation or by agricultural utilization. Potable water supply from groundwater and Lake Michigan may, as an option, be augmented by the reuse of reclaimed wastewater. The dispersed land treatment process sites offer some potential for power plant siting as a synergistic use of storage lagoons and land areas.

OVERVIEW OF IMPACTS

When land reclamation is employed for sludge management, the impacts judged to result from implementation of this alternative are remarkably similar to those attributed to Alternative III. A larger number of unfavorable impacts are attributed to the alternative when sludge disposal is by agricultural utilization.

ENVIRONMENTAL QUALITY

Health, Diversity and Productivity of Plants and Animals

A slightly negative impact on unique and rare things is perceived for this alternative, largely as a result of disruption during construction. The impact is less negative than that encountered with the wholly land treatment alternative (IV) but somewhat more negative than with the 17 plant AB alternative (III). Biotic communities, in general, are only slightly affected (mixed positive and negative impacts). On the whole, ecosystem status is reinforced quite strongly as was the case for Alternatives III and IV as well.

Preservation or Enhancement of Land, Air, and Water Resources.

The impacts common to all NDCP alternatives contribute to the strongly favorable impacts in this category. Soil quality is moderately enhanced as a result of the sludge utilization, an impact generally common to Alternatives III and IV as well. Air quality impacts are slightly negative as are mineral resource impacts. Both of these impacts arise from the treatment plants component of the alternative.

SOCIAL WELL BEING

Hygienic Characteristics

The impacts of alternative V on the hygienic characteristics of the region are generally favorable, reflecting the enhanced water quality

(surface and groundwater) provided by all NDCP treatment alternatives. The small impacts (mixed positive and negative) on air quality neither contribute to nor detract from the moderately positive impact on health and safety in an appreciable amount.

Aesthetic characteristics

This category of social well-being is enhanced most strongly of all by alternative V. Sensory quality of the environment (visual appearance, odors, noise, etc.) is moderately improved when land reclamation with sludge is employed, and slightly improved when agricultural application of sludge is used. The improvement in surface water quality also contributes strongly to the aesthetic characteristics of the region.

Social Characteristics

The overall impact of alternative V on social characteristics is positive: moderately so when sludge is utilized for land reclamation. The impacts on residential land use are slight and mixed (positive with land reclamation, negative with agricultural utilization of sludge). Access (to transportation, communication, public utilities, etc.) is moderately impeded because of construction activities and the space requirements for treatment facilities. All other aspects of social characteristics (recreation and open space, residential activity, immigration, and cultural-educational activities) are moderately to strongly enhanced as a result of the positive impacts on environmental quality and social well being described previously.

Economic Development

The optional variations within alternative V produce varying degrees of negative impact on economic development. As with all alternatives energy resources are most negatively impacted. Commercial and industrial land use is subjected to a slightly negative impact when power generation is not employed in the land treatment areas. As a consequence, commercial and industrial production are impacted negatively, as is construction. As was explained earlier, these impacts reflect competition between the private and public sections of the economy for the region's resources. Other aspects of economic development (employment, income, public and private servie, public finance, and food production) are slightly enhanced by the generally favorable environmental quality and social well-being accruing to the region. Failure to take advantage of the potential power synergism however produces slightly negative impacts in these categories when agricultural utilization of sludge is employed, again for reasons previously discussed.

DISCRIMINATING FEATURES OF THE NDCP ALTERNATIVES

Certain aspects of the NDCP alternatives were of significant value to the evaluation, since they displayed obvious differences between alternatives. The major differences in the impacts judged to result from the implementation of each of the NDCP alternatives (II through V) relate strongly to four features or characteristics of the alternatives: number of "treatment plants" (extent of decentralization as opposed to regionalization for economies of scale); type of treatment process employed; method for sludge management; and power generation at the land treatment sites. In the following paragraphs, the effect of each factor is discussed in terms of the manner in which it influences the overall impacts of the alternatives.

NUMBER OF "TREATMENT PLANTS"

The number of treatment plants or sites used in structuring an alternative reflects the extent of decentralization of that alternative. In general, the impacts are more favorable when larger numbers of plants or sites are employed, for the plants themselves tend to be smaller and more widely dispersed throughout the region. This, in turn, causes the wastewater collection systems to be shorter and less complex, with less disruption to the region during construction. Since the treated wastewaters are returned to the streams of the region at a multitude of sites to improve the streams' flow characteristics for navigation, recreation and flood control benefits, the conveyance system needed to redistribute the effluent throughout the region would also be simpler, require less energy for conveyance, be cheaper to operate and produce less disruption. Also, the effluent tends to be distributed somewhat more uniformly or desirably throughout the region with a decentralized system.

Recent studies have shown that the expected day-to-day variations in the performance of treatment plants can produce substantial variations in the quality of water in the streams receiving the effluents from these plants. These detrimental effects on stream quality are minimized by utilizing larger numbers of medium-sized plants in preference to small numbers of very large plants.

The impacts on relocation of people relating to decentralization are marked, in large measure, by the differences in treatment technology and sludge-management technology, but would probably also reflect the preference for decentralization.

TYPE OF TREATMENT PROCESS

The NDCP alternatives were designed around three technologies for wastewater treatment: advanced biological treatment (AB), physical-chemical treatment (PC), and land treatment by irrigation (Land). Favorable and unfavorable impacts were associated with each of the technologies, but in general the AB treatment provided the most favorable impact overall, PC treatment the most unfavorable. Land treatment was intermediate in overall impact. The quality and potential utility of the sludge produced by each technology also is a strong consideration. AB and Land sludge is of higher quality than PC sludge in terms of projected utilization for agriculture and other purposes.

Both land and AB treatment offer better utilization of resources than PC treatment, not only in terms of the sludge, but also in terms of the chemicals and other mineral resources consumed in the treatment processes. The potential value of the nutrients in wastewater used for irrigation was discounted by the buildup of heavy metals and other compounds in the soil giving an overall neutral impact.

Consideration of the air pollutant emissions expected from each of the technologies tends to favor land treatment over AB treatment, but both are clearly more favorable than PC, the emissions of which produced many of the negative impacts associated with this treatment technology.

SLUDGE MANAGEMENT

Two sludge management options were considered for the sludges produced by the AB and Land treatment technologies: land reclamation and agricultural utilization. In land reclamation, the sludges are used to develop new topsoil for surface-mined areas. Agricultural utilization involves the application of sludges to agricultural lands to serve as a soil builder as well as fertilizer.

The most favorable impacts were judged to result when the land reclamation option was adopted. In the judgment of the evaluators, it represented a higher and better use of resources, involved less displacement of people, and might even serve to encourage commerce and industry by making surface mining a more acceptable technolcgy.

Agricultural utilization of sludge was the only option proposed for PC sludge management. As such, agricultural utilization was a common option to all NDCP alternatives. However, the amount of land needed to receive the PC sludge was extremely large (about 1000 square miles, nearly 10 times the area required for AB or land sludge), and this alone was viewed as a negative impact of PC treatment. Also, the sludge itself was considered to be of lesser value than AB or Land treatment sludge. Overall, the agricultural utilization option for sludge management tended to favor AB or land treatment as preferred to PC treatment.

POWER GENERATION AT LAND SITES

The lagoons and associated lands needed as part of the land treatment technology offered the opportunity for complementary use in power generation, since the land areas could provide the necessary isolation and buffer zone for the generating station and the lagoons could be utilized as cooling ponds. In considering the impacts associated with this complementary use, the evaluators assumed that future demands for power would be met by generating capacity built within the C-SELM region in accordance with FPC projections. Their evaluation, then, reflected the preference for generating power at the land treatment sites as opposed to elsewhere in the region. As a result, strongly favorable impacts were associated with the synergism of power generation and land treatments again a manifestation of the efficient use of resources. Indeed, it is with this efficient use of resources (power generation) that Alternative V (5 AB plants plus 6 land treatment sites) becomes nearly identical to Alternative III (17 AB plants, no power) in the array of

impacts produced. Power generation also improves the favorability of impacts associated with Alternative IV (land treatment).

NUMERICAL ESTIMATES OF IMPACTS

A numerical procedure was used in the evaluation of the impacts expected of the wastewater management alternatives. The procedure and its results are described in detail in later sections of this report. The following tables have been reproduced from these sections and are presented here only to reinforce visually the verbal descriptions of impact presented in this section. The reader should refer to the later sections of this report for a complete description and interpretation of the tables

Table E-I-1 taken from Section III displays the array of impacts on the primary (largely environmental) dimensions for each alternative in each of its variant forms. The shaded areas highlight the dimensions and alternatives where negative impacts arise.

The impact scores presented in Table E-I-1 were translated into resultant impacts on human activities. The resultant impact scores for the human activity dimensions are presented in Table E-I-2 (taken from Section IV), again arranged by alternative (and by variation within alternative). Negative impacts have been highlighted here as well.

RANKING OF ALTERNATIVES

The evaluation procedure was designed so that the impact assessments made in the environmental and social dimensions could be combined to produce a composite total impact score for use in ranking the alternatives. Detailed analyses of these rankings are presented in Section IV and Annex B of this report. The following paragraphs are intended to provide a cursory overview of the results.

RANKING BY AVERAGE IMPACTS

The averages of the subjective assessments assigned by each evaluator for each impact dimension were combined to produce an overall impact score for each of the possible variations of the alternatives (systems). When the alternatives were ranked according to this procedure, Alternative III (17 advanced biological treatment plants) and Alternative V(5 advanced biological treatment plants plus 6 land treatment sites) with sludge management by land reclamation and (for the land treatment sites) power generation were found to be very close in score at the top (most favorable end) of the impact scale. Reuse of treated effluent was preferred over excessive withdrawals from Lake Michigan for the potable water supply.

Alternative IV, the land treatment process, first appears in the rankings in 7th and 8th place, again with land reclamation and power generation at the treatment sites.

At the bottom end of the impact rankings are Alternative I, the 64 plant conventional biological (reference) alternative and Alternative II, the 33 plant physical-chemical treatment system.

The reader should refer to Section IV, Table E-IV-3 and Figure E-IV-3 for a complete presentation of the rankings by this method.

UNBIASED AVERAGE OF INDIVIDUAL EVALUATORS' RANKINGS

Just as the average assessments of impact were used to complete an overall impact score for the ranking of alternatives, the individual impact assessments of each evaluator were used to calculate overall impact scores peculiar to that individual. The scores and rankings calculated in this way were analytically combined to reveal that the 13* evaluators could be consolidated into seven independent viewpoints of impact. When these seven viewpoints were given equal weighting, the average of the impact scores from the seven viewpoints provides an "unbiased" evaluation of the overall impact in that all viewpoints are represented equally. These results are discussed more fully in Annex B of this report.

Following this approach to impact ranking, the best three variations in Alternatives were from type III, IV and V in that order. The worst alternative was type II, the PC alternative.

Alternative III, in its variations, produced the best average ranking. Alternatives IV and V, in their variations, were virtually tied for second place in the average ranking. Alternative I was in fourth place, while Alternative II was in fifth (last) place.

Again, sludge management by land reclamation was preferred to agricultural utilization; reuse was preferred for potable water supply; and power generation at the land disposal sites was preferred, where possible, to power generation elsewhere in the C-SELM region.

*Mr. Strawhun did not participate in the numerical evaluation. He did participate in the group discussions as well as offering narrative comments.

TABLE E-I-1

TOTAL SYSTEM IMPACTS IN THE PRIMARY DIMENSIONS[1]

System Type	System Number	Sludge Management	Potable Supply	Power	Recreation & Open Space	Surface Water Quality	Surface Water Quantity	Groundwater Quantity	Soil Quality	Sensory Quality	Groundwater Quality	Agricultural Land-Use	Mineral Resources	Comm. & Ind. Land Use	Air Quality	Biotic Communities	Residential Land-Use	Unique or Rare Things	Access	Energy	System Score (Row Sum)
					10	1	2	4	11	6	3	9	12	8	5	15	7	16	14	13	
I-Ref	1	Ag.	L.M.		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
II-R.C.	3	Ag.	Reuse		2.3	2.4	3.0	1.3	-0.2	-0.8	0.5	-0.8	-2.2	0.6	-1.9	-1.0	-0.3	-0.5	-0.1	-5.2	-2.9
	2	Ag.	L.M.		1.9	2.5	2.6	1.0	-0.1	-0.6	0.6	-0.8	-2.4	0.4	-2.0	-1.0	-0.4	-0.7	-0.3	-5.0	-4.5
III-A.B.	7	Land	Reuse		3.9	3.4	3.1	1.3	1.6	2.8	1.5	0.4	-0.3	0.6	0.2	0.6	1.4	-0.5	-0.2	-4.9	14.9
	6	Land	L.M.		3.5	3.5	2.7	1.2	1.7	3.0	1.6	0.4	-0.5	0.4	0.1	0.4	1.3	-0.7	-0.4	-4.7	13.3
	5	Ag.	Reuse		2.4	3.1	3.1	1.1	1.5	1.2	1.2	0.8	-0.5	0.1	-0.3	0	0.1	-0.7	-0.5	-4.3	8.3
	4	Ag.	L.M.		2.0	3.2	2.7	0.8	1.6	1.4	1.3	0.8	-0.7	-0.1	-0.4	-0.2	0	-0.9	-0.7	-4.1	6.7
IV Land	14	Land	Reuse	Yes	4.4	3.6	3.0	1.8	1.9	2.4	0	0.2	1.0	0.4	0.4	-0.2	-0.1	-1.4	-2.1	-5.0	10.3
	15	Land	L.M.	Yes	4.0	3.7	2.6	1.5	2.0	2.6	0.1	0.2	0.8	0.2	0.3	-0.4	-0.2	-1.6	-2.3	-4.8	8.7
	12	Land	Reuse		4.2	3.1	3.1	1.7	1.6	2.2	0	-0.3	0.8	-0.6	0.5	-0.2	-0.5	-1.4	-1.9	-6.5	5.8
	13	Land	L.M.		3.8	3.2	2.7	1.4	1.7	2.4	0.1	-0.3	0.6	-0.8	0.4	-0.4	-0.6	-1.6	-2.1	-6.3	4.2
	11	Ag.	Reuse	Yes	2.8	2.9	3.1	1.9	1.5	0.9	-0.6	0.4	0.9	0	0	-0.9	-1.5	-1.7	-2.4	-4.3	3.1
	10	Ag.	L.M.	Yes	2.4	3.0	2.7	1.6	1.6	1.1	-0.5	0.4	0.7	-0.2	-0.1	-1.1	-1.6	-1.9	-2.6	-4.0	1.5
	9	Ag.	Reuse		2.6	2.4	3.2	1.8	1.2	0.7	-0.6	-0.1	0.7	-1.0	0.1	-0.9	-1.9	-1.7	-2.2	-5.7	-1.4
	8	Ag.	L.M.		2.2	2.5	2.8	1.5	1.3	0.9	-0.5	-0.1	0.5	-1.2	0	-1.1	-2.0	-1.9	-2.4	-5.5	-3.0
V Land + A.B.	23	Land	Reuse	Yes	5.0	3.6	3.7	2.2	1.9	2.0	0.9	0.7	0.3	0.5	0.2	0.5	0.8	-1.1	-1.2	-4.3	15.7
	22	Land	L.M.	Yes	4.6	3.7	3.3	1.9	2.0	2.2	1.0	0.7	0.1	0.3	0.1	0.3	0.7	-1.3	-1.4	-4.1	14.1
	21	Land	Reuse		4.9	3.2	3.5	2.0	1.7	2.1	0.8	0.4	0.1	-0.1	0.3	0.5	0.5	-1.0	-1.1	-5.6	12.2
	20	Land	L.M.		4.5	3.3	3.1	1.7	1.8	2.3	0.9	0.4	-0.1	-0.3	0.2	0.3	0.4	-1.2	-1.3	-5.4	10.6
	19	Ag.	Reuse	Yes	3.1	3.2	3.8	2.3	1.7	0.4	0.4	0.8	0	0	-0.3	-0.1	-0.6	-1.3	-1.6	-3.6	8.2
	18	Ag.	L.M.	Yes	2.7	3.3	3.4	2.0	1.8	0.6	0.5	0.8	-0.2	-0.2	-0.4	-0.3	-0.7	-1.5	-1.8	-3.4	6.6
	17	Ag.	Reuse		3.0	2.8	3.6	2.1	1.5	0.5	0.3	0.5	-0.2	-0.6	-0.2	-0.1	-0.9	-1.2	-1.5	-4.9	4.7
	16	Ag.	L.M.		2.6	2.9	3.2	1.8	1.6	0.7	0.4	0.5	-0.4	-0.8	-0.3	-0.3	-1.0	-1.4	-1.7	-4.7	3.1

1 - The positive (+) or negative (-) numbers presented on this table do not connote beneficial or detrimental (i.e. good or bad). These figures present subjective assessment of the direction and magnitude of change, without deciding whether that change is given a value of good or bad.

TABLE E-I-2

TOTAL SYSTEM IMPACTS IN THE HUMAN ACTIVITY DIMENSIONS[1]

ALTERNATIVE	SYSTEM NUMBER	SLUDGE MANAGEMENT	POTABLE SUPPLY	POWER	AESTHETICS	ECOSYSTEM STATUS	RECREATION	HEALTH AND SAFETY	RESIDENTIAL ACTIVITY	FOOD PRODUCTION	IMMIGRATION	CULTURAL-EDUCATIONAL	POPULATION DENSITY	COMMUNITY SOCIAL STRUCTURE	COMMUNITY POLITICAL STRUCTURE	PUBLIC SERVICE	PUBLIC FINANCE	INCOME	PRIVATE SERVICE	EMPLOYMENT	CONSTRUCTION SERVICE	COMMERCIAL PRODUCTION	INDUSTRIAL PRODUCTION	SYSTEM SCORE (UNIT H VECTOR)
					16	17	15	10	7	3	8	13	9	19	18	5	14	12	6	11	4	1	2	
I-Ref	1	Ag	L.M.		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
II-PC	3	Ag	Reuse		7.5	9.7	8.8	-0.0	-1.8	-4.4	-1.1	-2.8	-3.0	-1.9	-2.1	-1.0	-2.7	-4.3	-2.1	-5.2	-7.2	-5.6	-8.2	-28.3
	2	Ag	L.M.		5.8	8.3	[illegible]	-1.3	-3.2	-4.8	-2.3	-4.2	-3.6	-2.3	-2.5	-2.1	-3.5	-5.2	-3.2	-6.2	-8.1	-6.6	[illegible]	-47.9
III AB	7	Land	Reuse		34.3	30.2	31.6	16.7	18.8	8.2	12.7	9.7	5.7	5.0	5.5	6.4	5.5	5.4	5.0	4.0	0.6	1.1	-5.5	202.1
	6	Land	L.M.		32.6	28.8	29.3	16.3	17.4	7.8	11.5	8.3	6.1	4.6	5.1	5.3	4.7	4.5	3.9	3.0	-0.7	0.3	-6.7	152.5
	5	Ag	Reuse		23.8	23.3	21.8	10.2	9.3	8.8	5.4	3.5	1.8	1.6	1.9	2.6	2.0	1.7	1.3	0.2	-1.9	-1.1	-4.8	111.3
	4	Ag	L.M.		22.1	21.9	19.5	9.8	7.9	8.4	4.2	2.1	1.2	1.2	1.5	1.5	1.2	0.8	0.8	-0.8	-2.8	-2.1	-6.0	91.7
IV Land	14	Land	Reuse	Yes	30.4	28.5	27.1	13.9	11.6	5.8	8.3	7.6	4.7	2.5	2.6	2.5	2.9	2.0	0.6	0.7	-2.2	-2.6	-5.5	138.7
	15	Land	L.M.	Yes	28.7	27.1	24.8	13.5	10.2	5.4	7.1	7.2	4.1	2.1	2.2	1.4	2.1	1.1	-0.5	-0.3	-3.1	-3.6	-6.5	119.1
	12	Land	Reuse		30.2	29.1	25.7	12.0	7.5	2.7	5.0	3.1	2.2	2.1	1.3	-0.7	-0.2	-2.0	-2.8	-4.4	-6.5	-8.0	-11.1	85.1
	13	Land	L.M.		28.5	27.7	23.4	11.6	6.1	2.3	3.8	1.7	1.6	1.7	0.9	-1.8	-1.0	-2.9	-3.9	-5.4	-7.4	-9.0	-12.3	65.5
	11	Ag	Reuse	Yes	15.2	19.6	15.9	6.5	2.0	5.1	1.3	-2.1	0.1	-1.0	-1.1	-1.3	-0.3	-1.5	-3.0	-2.7	-4.2	-4.6	-3.2	43.7
	10	Ag	L.M.	Yes	16.5	18.2	13.6	6.1	0.6	4.7	0.1	-3.5	-0.5	-1.4	-1.5	-2.4	-1.1	-2.5	-4.1	-3.7	-5.1	-5.6	-4.4	24.1
	9	Ag	Reuse		18.0	20.2	14.5	4.6	-2.1	2.0	-2.0	-3.6	-2.4	-1.4	-2.4	-4.5	-3.4	-5.6	-6.4	-7.8	-8.5	-10.0	-9.0	-9.9
	8	Ag	L.M.		16.3	18.8	12.2	4.2	-3.5	1.6	-3.2	-5.0	-3.0	-1.8	-2.8	-5.6	-4.2	-6.5	-7.5	-8.8	-9.4	-11.0	[illegible]	-29.5
V Land + AB	23	Land	Reuse	Yes	34.9	32.0	33.2	16.9	18.3	9.9	12.3	8.5	6.8	4.3	4.4	6.4	5.5	5.2	4.7	4.4	0.6	1.1	-2.6	207.2
	22	Land	L.M.	Yes	33.2	30.6	30.9	16.5	16.9	9.5	11.1	7.1	6.2	3.9	4.0	5.3	4.7	4.3	3.6	3.4	[illegible]	0.1	-3.8	187.6
	21	Land	Reuse		35.0	32.6	32.0	15.3	14.6	6.9	9.4	7.5	4.5	3.9	3.4	3.6	2.8	1.9	1.8	0.1	-1.3	-3.3	-8.1	161.3
	20	Land	L.M.		33.3	31.2	29.7	14.9	13.2	6.5	8.2	6.1	3.9	3.5	3.0	2.5	2.0	1.0	0.7	-0.9	-4.0	-4.3	-9.3	141.7
	19	Ag	Reuse	Yes	22.8	23.8	21.8	9.6	8.5	9.9	4.9	1.8	1.8	0.7	0.7	2.3	2.1	1.3	0.7	0.7	-1.8	-1.4	-1.1	109.2
	18	Ag	L.M.	Yes	21.1	22.4	19.5	9.2	7.1	9.4	3.7	0.4	1.2	0.3	0.3	1.2	1.3	0.4	-0.4	-0.4	-2.7	-2.4	-2.3	89.6
	17	Ag	Reuse		22.9	24.4	20.6	8.0	4.8	6.9	2.0	0.8	-0.5	0.3	-0.3	-0.5	-0.6	-2.0	-2.2	-3.7	-5.5	-5.8	-6.6	63.3
	16	Ag	L.M.		21.2	23.0	18.3	7.6	3.4	6.4	0.8	0.6	-1.1	-0.1	-0.7	-1.6	-1.4	-2.9	-3.3	-4.7	-6.4	-6.8	-7.8	43.7

1 - The positive (+) or negative (-) numbers presented on this table do not connote beneficial or detrimental (i.e. good or bad). These figures present subjective assessment of the direction and magnitude of change, without deciding whether that change is given a value of good or bad.

SECTION II: EVALUATION METHODOLOGY

PURPOSE

The basic purpose of the evaluation procedure is to assure that the regional wastewater management alternatives developed for the Chicago-South End of Lake Michigan Area (C-SELM) are harmonious with the social and physical environment. More particularly, the purpose of impact evaluation is:

(1) to show how each alternative system affects human values and goals directly and indirectly by means of performance and concomitant effects transmitted through changes in resources and environment (including economic and social as well as physical changes); and

(2) to compare the impacts of the several alternative systems in such a way that the relative desirability of the several systems can be determined qualitatively and, if possible, quantitatively.

A further purpose is to suggest areas where design revisions may reduce undesirable impacts or enhance desirable impacts. To this end, the evaluation procedure is specifically structured to explicitly identify the relationships between overall impacts and the specific system components contributing to those impacts.

OVERVIEW OF METHODOLOGY

It was evident at the start of this effort that the state-of-the-art and the available data could not support the development and application of an analytic, objective evaluation procedure. Furthermore, given the preliminary nature of the C-SELM study, it was also clear that a complex, mathematical approach involving forecasting models would not provide the kind of information required by designers, regional policy-makers, and citizens. Traditional economic evaluation approaches, such as cost-benefit analysis, could not effectively capture the breadth of impacts likely to occur due to the implementation of a large scale wastewater treatment scheme. On the other hand, it was also clear that a variety of technical professionals could contribute to the identification and evaluation of social-environmental impacts through the application of their trained, subjective judgment. It would be necessary, of course, to involve a group of qualified evaluators, since no one individual could possess the knowledge required to assess all the impacts. This had to be accomplished in a systematic fashion to insure that the resulting product would not only identify the most and least desirable alternatives, but would also describe why such alternatives were good or bad.

A number of subjective impact assessment techniques have been reported in the literature, but each of these is deficient in some way. For example, the concept of displaying subjective estimates of environmental consequences of public investments in the form of tables or matrices has been proposed and applied by several researchers. Generally these techniques treat alternative systems as large, indivisible units, requiring that evaluators capture the particular impacts of all aspects of each alternative in a single judgment. Yet the concepts proposed for the C-SELM area are of such scale and complexity that one can only hope to understand them by dealing with each of their component parts separately. In addition, the processes by which the impacts themselves take place are too complex to be treated effectively by single, subjective judgments. Thus it seemed desirable to examine the impact process in a step-by-step fashion. Therefore, there was a need to disaggregate the evaluation from the points of view of both the components of the alternatives and the impact development process.

A second problem associated with available subjective evaluation methods is that they have been designed primarily for use by single evaluators. Their structures and application processes do not facilitate the use of groups of expert evaluators. Yet the breadth of impacts likely to occur due to the implementation of the C-SELM wastewater management alternatives exceed the comprehension and knowledge of any single evaluator.

Finally, available methods were very general in nature, and did not respond to the specific characteristics of the C-SELM design concepts. Therefore, such methods did not support a systematic evaluation of the alternatives to be considered in this study.

These deficiencies, in light of the nature of the problem of evaluating the C-SELM alternatives, provided guidelines for the development of a new, advanced, and more responsive strategy for evaluation. The strategy described and applied here considers the impacts of the various components of each alternative, treats the impact process as a multi-step process, promotes interaction between--and captures the judgments of--a group of technical evaluators, and responds to the specific nature of the C-SELM alternatives. The evaluation methodology is used also as a tool to stimulate the evaluators in preparing verbal descriptions of the impacts. Furthermore, experience has shown that the evaluation methodology has the capability to clearly differentiate between alternative system designs and to identify the factors influencing the preferences of the evaluators. It exhibits highly consistent performance over a series of evaluation rounds, and it is easily adapted to new alternatives and new viewpoints. Finally, while the approach may appear to be somewhat complex, it was found that evaluators from a variety of backgrounds had little difficulty in understanding and working with the technique.

The approach taken was the development of a series or chain of impact tables (matrices) through which the impact of a particular system component could be traced quantitatively, first on a set of primary impact (largely environmental) dimensions and, through them, on a set of human activities.

Independently, the relative desirability of enhancing or reinforcing each of these human activities within the study area (C-SEIM) could be estimated, thereby providing a weighting scale for the activities. Once the impacts had been assessed through the primary impact (environmental) dimension to the human activities, the activities weighting scale could be applied to the impacts and the weighted impacts summed over all activities to produce a total score for that system element. The algebraic sum of the scores for all elements comprising a system becomes the system score.

The A-matrix describes the magnitude and direction of the impacts of each element of the alternative systems on the primary social-environmental dimensions. The B-matrix describes the magnitude and direction of the effect of a change in each primary social-environmental dimension on each of an identified set of important human activities. The product of the A and B matrices, the C-matrix, relates system elements to human activity impacts. The vector V describes the relative importance of each human activity; when multiplied times the C-matrix, it produces a total human impact score for each system component. System scores may then be developed by adding the appropriate element scores.

From a mathematical standpoint, the evaluation procedure is best described as a sequence of matrix and vector multiplications.

$$\begin{bmatrix}\text{Matrix}\\ \text{A}\end{bmatrix} \times \begin{bmatrix}\text{Matrix}\\ \text{B}\end{bmatrix} = \begin{bmatrix}\text{Matrix}\\ \text{C}\end{bmatrix}$$

Primary Impacts of System Elements	Translation of Primary Impacts into Human Activities Impacts	Human Activities Impacts of System Elements

$$\begin{bmatrix}\text{Matrix}\\ \text{C}\end{bmatrix} \times \begin{bmatrix}\text{Vector}\\ \text{H}\end{bmatrix} = \text{System Element Impact Scores}$$

Human Activities Impacts of System Elements	Human Activities Weights

Each of these components will be described in greater detail subsequently.

EVALUATION PANEL

An evaluation panel was assembled from the faculties and staffs of Northwestern University (Illinois) and the Northwest Consortium (Indiana). The panel represents expertise in a wide variety of disciplines encompassing the physical and social sciences, engineering and resource planning and management.

The function of the evaluation panel was fourfold:

(1) to construct (through group consensus) the lists of primary impact and human impact dimensions (elements) through which the impacts are assessed;

(2) to assess the magnitude and direction of impact for each impact linkage (system element to primary impact dimension; primary impact dimension to human impact dimension); and to assess the relative priorities to be assigned to the various human activities;

(3) to prepare written comments on the nature of the impacts; and

(4) to suggest opportunities for redesign of alternatives or their elements.

Members of the evaluation panel have also played a significant role in promoting the structured evolution of the evaluation methodology itself, thereby assuring that the methodology is responsive to the characteristics of the alternatives and their impacts. The evaluators used the method described in this report during three separate system evaluation rounds. After each round, a report was compiled to serve as the basis for redesign prior to the next round. This report focuses on the results of the third, and final, round.

At the start of an evaluation each evaluator was provided with extensive written documentation (engineering specifications) on the characteristics of the alternatives. A formal briefing session normally lasting an entire day, was then held to allow evaluators to clarify their impressions of the alternatives and provide an opportunity for the exchange of ideas. Similarities and differences among systems or system elements were stressed. Then each evaluator independently assessed the magnitude (0 to 3) and direction (+ or -) of impact for each element of each impact table. Concurrently, he prepared written commentary on his assessments to aid in interpreting the evaluations and to allow for inclusion of verbal information not well suited to the quantitative evaluation. Once the individual assessments were completed, the results for all evaluators were used to score the systems. These same tables and the overall system scores and comments were presented to the panel in a collective debriefing session, and additional comments and overall impact evaluations were developed. At this point, evaluators were given the opportunity to revise their numerical impact estimates and to make additional written comments.

These formed the basis of the impact evaluation report. The report is intended to provide information to support the selection and not to make the selection of the most appropriate alternative for implementation from a regional social-environmental perspective.

It is important to recognize that each of the dimensions of impact is, itself, a complex multifaceted entity. The totality of impact in each dimension is the aggregate of impacts ascribed to the many sub-dimensions which comprise it. Each evaluator, when assessing impact in a particular dimension, called upon his own special competencies or expertise to identify those sub-dimensions of impact on which his assessment was based and the magnitude of impact in those sub-dimensions. Group * consensus was not expected. Rather, the accumulation of impacts over the broad variety of disciplines represented by the evaluation team insured that each dimension of impact was considered from a variety of viewpoints and that the total (or average) impact ascribed to that dimension was the best overall estimate of impact. As will be shown later, the diversity of assessments among the members of the evaluation panel was used to identify a variety of viewpoints from which the impacts of the wastewater management alternatives may be assessed. (See Annex B. This annex is highly technical and will be of greatest use to those persons familiar with the types of analysis performed.)

ALTERNATIVES, ELEMENTS AND SYSTEMS

Each of the five wastewater management alternatives considered in this final round is comprised of a number of functional components, some of which are unique to a particular alternative, while others are common to several alternatives. In addition, optional components have been identified whereby certain functions of an alternative may be dealt with in two different ways. For two alternatives, optional additional functions have been identified and characterized as "add-on" components. The major categories of functional components are the following:

Collection, transportation and storage of incoming wastewater (including stormwater collection and treatment, where applicable);

Wastewater treatment processes and facilities;

Sludge management methods;

Treated water quality and patterns of distribution (throughout the C-SELM area) for navigation and recreation;

Potable water supply or reuse strategies;

Power generation (as an add-on to the land treatment alternatives).

The use of optional components within the several major functional categories required the identification of sub-components or elements describing each variation in design of a functional component. For example, the

*Advantage of group evaluation: resulted in communications between disciplines; group meetings were held to strengthen the analyses.

collection, transportation and storage element of a 33 plant system was different from that of a 17 plant system. A particular wastewater management alternative can be described, then, by a set of elements selected from the six functional categories, one element from each category. If an optional element for any alternative exists within a particular category, such as sludge disposal by agricultural utilization or by land reclamation, two sets of elements for that alternative were identified, differing only in particular optional elements included in each set.

It is useful to consider each set of elements as representing a wastewater management system, in as much as it represents a complete alternative in one of its variant forms. For any particular alternative, a number of systems (different sets of elements) may exist all of which together express the possibilities for variation within that alternative.

SYSTEM ELEMENTS (S-VECTOR):

A modular approach was taken to the identification of system elements. Each system was analyzed in terms of the independent elements of which it is composed. These components make up the "S" vector.

Because there are interactions among the major categories of functional components described previously, it is necessary to cross-classify into independent elements. For example, evaluation of the sludge management impact must consider not only the particular type of sludge management proposed, but also the nature of the treatment process that has produced the sludge. The comprehensive "S" vector for the wastewater management alternatives is as follows:

Collection, Transportation and Storage.

Included in this category are all wastewater and storm water collection systems, access points and pumping stations, tunnels, and other appurtenances needed to convey the wastewater and storm water to the appropriate treatment facilities. Where treatment of separate storm water is proposed, those facilities are included; and the "open space" potential of specialized storm water storage and treatment facilities is also evaluated in this category.

Since the impacts of this category vary among the systems according to the level of aggregation of the treatment facilities, (the number of treatment plants in the region) the following independent subcategories were utilized in the evaluation:

1. 64 plant system without treatment of separated storm water (reference system);

2. 33 plant system, meeting the No Discharge of Critical Pollutants (NDCP) standard;

3. 17 plant system, NDCP;

4. Land Disposal, distributed sites, NDCP;

5. 5 plant plus distributed land system, NDCP.

Treatment Processes and Facilities.

This category requires that the treatment facilities and process be viewed as "factories" with attendant impacts transmitted through: the number, size (space), and location of such facilities; the aesthetic characteristics such as noise and appearance, etc.; air pollution and odors; and the resources consumed in the construction and operation of the facilities. Where land disposal systems are involved, the impact of the open space acquired under the land system is evaluated here. Note, however, that the impacts of liquid effluent and sludge disposal are evaluated elsewhere.

The subcategories differ according to the number and location of facilities and treatment processes involved:

6. 64 plant conventional biological treatment system (CB);

7. 33 plant physical-chemical treatment system (PC);

8. 17 plant advanced biological treatment system (AB);

9. Land - disbributed treatment sites (DL);

10. 5 AB plants plus distributed land sites (5 AB + L).

Sludge Management Methods.

All aspects of sludge management are considered within this category, including the transportation of the sludge to the disposal site and storage facilities as needed. Open space impacts of the sludge disposal areas are included.

The subcategories differ according to the number and location of disposal sites and the type of sludge involved:

11. Agricultural disposal, conventional biological sludge (Ag. CB);

12. Agricultural disposal, PC sludge (Ag. PC);

13. Agricultural disposal, AB sludge (Ag. AB);

14. Agricultural disposal, distributed land system (Ag. L);

15. Agricultural disposal, 5 AB + distributed land (Ag. AB + L);

16. Land reclamation, AB or land treatment sludge (Land).

Liquid Effluent Quality and Distribution for Navigation and Recreation.

The major impacts of the several wastewater management systems on the water resources of the region are transmitted through this category. Included are such factors as effluent and stream water quality standards; effluent distribution throughout the region for navigation, recreation and stream use; but not supply of water to potable water need centers. The impact of transportation facilities needed to redistribute the water throughout the region is a significant consideration here.

Although the exact quantities of water placed in each stream of the region will differ only slightly according to the number and location of treatment facilities, the extent of the conveyance system is heavily dependent on the number and location of treatment facilities. The subcategories reflect these variations:

17. Navigation - recreation, 64 plants;

18. Navigation - recreation, 33 plants;

19. Navigation - recreation, 17 plants;

20. Navigation - recreation, distributed land;

21. Navigation - recreation, 5 AB + distributed land.

Potable Water Supply or Reuse.

In this category, the impacts of two alternative approaches to meeting the future demands for potable quality water were considered: continued withdrawal of Lake Michigan water to supplement groundwater supplies or the recycling of substantial quantities of treated wastewater for reuse so as to avoid exceeding the present allotment for diversion of Lake Michigan water. In either case, it is presumed that the water would be further processed (by water treatment plants) before use as a potable supply. The subcategories or elements are:

22. Potable needs supplied through additional diversion from Lake Michigan (LM);

23. Potable needs supplied (in part) by reuse of treated wastewater (R).

Power Synergism

Although power generation is not specifically a part of wastewater treatment the land treatment alternatives utilize certain components as part of the treatment process that could be used in combination with power generation: large tracts of land and large wastewater ponds that could be used for cooling. For the purpose of impact evaluation, it was assumed that future increases in power demand in the C-SELM region will be met by

power generating stations built within the area. The impact of siting such power plants within the proposed land disposal areas for Alternatives IV and V was evaluated relative to the impacts of siting such plants elsewhere within the C-SELM area. The system elements are:

24. Power at undesignated location in C-SELM, not linked to the wastewater management system;

25. Power plants located within some distributed land treatment sites;

26. Power plants located within some land sites in the 5 plant plus land system.

The 26 subcategories comprise the comprehensive S vector (list of system components) representing all elements of all alternative systems. Each system can be described and evaluated using one subcategory from each major category. In the following system matrix, Table E-II-1, the subcategories for each system are identified by the locations of the 1's in the matrix row associated with that system. Wherever options exist, the optional subcategories are identified with 2's. The 26 elements describing the 5 alternatives can be combined in 23 different ways or variations. Thus, the 5 alternatives, with options, are in reality 23 distinct systems. These systems, and the system elements comprising each, are described in Table E-II-2, Alternative I requires but one system to describe its variations; Alternative II requires 2 systems; Alternative III requires 4 systems; Alternative IV requires 8 systems; and Alternative V requires 8 systems.

C-SELM REGION

For the purpose of evaluating impacts produced by wastewater management alternatives, the Chicago-South End of Lake Michigan Region was defined to include not only the basic area surrounding Lake Michigan, but also such interior lands as are traversed by or utilized as part of any wastewater management or sludge management system. The impacts are reported in terms of the aggregate effect over all areas involved, and are not specific to any local area.

PRIMARY IMPACTS OF SYSTEM ELEMENTS (MATRIX A)

In this table the linkages between system elements and primary impact dimensions are identified so that the impact of each system element on each primary impact dimension can be assessed.

Primary Impact Dimensions (E Vector): A primary impact dimension is defined as something in the environment that is a plausible candidate for change (impact) resulting from the construction or operation of the system elements. An attempt has been made to cover the whole range of primary impact change in independent categories that are general and

TABLE E-II-1
SYSTEMS MATRIX

1 = Principal component of indicated system 2 = Optional alternative component (within category) of indicated system

Systems Components	Collection, Transportation & Storage of Input Water					Treatment Facilities & Processes					Sludge Management						Water Effluent Distribution and Quality					Potable Supply		Power Synergism				
Vector S	64 plant	33 plant	17 plant	Distributed land	5 plant + land	64 plant conv. bio.	33 plant P.C.	17 plant AB	Distributed land	5 plant AB + land	Agric. disp.,conv. bio.	Agric. disp., P.C.	Agric. disp., AB	Agric. disp., dist. land	Agric. disp., AB + land	Land reclam. AB or land	Navig.-Rec., 64 plant	Navig.-Rec., 33 plant	Navig.=Rec., 17 plant	Navig.-Rec., distrib. land	Navig.-Rec. 5 plant + land	Potable Needs from L. Mich.	Potable Needs from Reuse	Power Synergism-Undesignated location	Power Synergism-distributed land	Power Synergism-5 plant plus land		
Alternative	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26		
I(ref)	1					1					1						1					1		1				
II		1					1					1						1				1	2	1				
III			1					1					1			2			1			1	2	1				
IV				1					1					1		2				1		1	2	1	2			
V					1					1					1	2					1	1	2			2		

TABLE E-II-2

SYSTEM LIST -- NUMERICAL ORDER

SYSTEM NUMBER	*SYSTEM TYPE	SYSTEM DESCRIPTION				SYSTEM ELEMENTS
		Plant	Sludge	Potable Supply	Power	
1	I	64	agr	L.M.	no	1,6,11,17,22,24
2	II	33	agr	L.M.	no	2,7,12,18,22,24
3	II	33	agr	R.	no	2,7,12,18,23,24
4	III	17	agr	L.M.	no	3,8,13,19,22,24
5	III	17	agr	R.	no	3,8,13,19,23,24
6	III	17	land	L.M.	no	3,8,16,19,22,24
7	III	17	land	R.	no	3,8,16,19,23,24
8	IV	DL	agr	L.M.	no	4,9,14,20,22,24
9	IV	DL	agr	R.	no	4,9,14,20,23,24
10	IV	DL	agr	L.M.	yes	4,9,14,20,22,25
11	IV	DL	agr	R.	yes	4,9,14,20,23,25
12	IV	DL	land	R.	no	4,9,16,20,23,24
13	IV	DL	land	L.M.	no	4,9,16,20,22,24
14	IV	DL	land	R.	yes	4,9,16,20,23,25
15	IV	DL	land	L.M.	yes	4,9,16,20,22,25
16	V	5+L	agr	L.M.	no	5,10,15,21,22,24
17	V	5+L	agr	R.	no	5,10,15,21,23,24
18	V	5+L	agr	L.M.	yes	5,10,15,21,22,26
19	V	5+L	agr	R.	yes	5,10,15,21,23,26
20	V	5+L	land	L.M.	no	5,10,16,21,22,24
21	V	5+L	land	R.	no	5,10,16,21,23,24
22	V	5+L	land	L.M.	yes	5,10,16,21,22,26
23	V	5+L	land	R.	yes	5,10,16,21,23,26

* I refers to conventional biological, II to physical-chemical, III to advanced biological, IV to distributed land, and V to a 5 plant plus land treatment system.

simple enough to be understood by the evaluators. The dimensions are as follows:

1. Surface Water Quality;
2. Surface Water Quantity (temporal and spatial availability; flood prevention or diminution);
3. Subsurface Water (Groundwater) Quality;
4. Subsurface Water (Groundwater) Quantity (availability);
5. Air Quality;
6. Sensory Quality of the Environment (appearance, noise, odor, etc);
7. Residential Land Use (Present and potential);
8. Commercial and Industrial Land Use (Present and potential);
9. Agricultural Land Use (Present and potential);
10. Recreation and Open Space Land (Present and potential);
11. Soil Quality;
12. Mineral Resources;
13. Energy;
14. Access (transportation, communication, water and wastewater service);
15. Biotic Communities (terrestrial and aquatic);
16. Unique or Rare Things or Species.

For each dimension, a check list was prepared to guide the evaluators as to the kinds of impacts to be included in that dimension. The check list was not intended to be comprehensive or exhaustive but simply illustrative. Each evaluator was free to determine the components he felt to be relevant to that dimension. The check list for Primary Impact Dimensions (E vector) is shown as Table E-II-3.

The impact of each system element on each primary impact dimension was rated on a scale of -3 (extremely negative) to +3 (extremely positive), with positive connoting improvement or enhancement. A neutral impact (score = 0) could have been assigned if desired. For example, a storm water collection system might have a +2 impact (moderately positive) on surface water quality but a -1 impact (slightly negative) on energy. The rating form used by the evaluators to assess these direct impacts is shown

as Table E-II-4. In completing the form, each evaluator answered the following questions for each system element:

1. Surface water quality
   To what extent will the quality of surface water be improved (+) or degraded (-)?

2. Surface water quantity
   To what extent will the spatial and temporal distribution of surface water be improved (+) or degraded (-)?

3. Subsurface water quality
   To what extent will the quality of subsurface water be improved (+) or degraded (-)?

4. Subsurface water quantity
   To what extent will the availability of subsurface water increase (+) or decrease (-)?

5. Air quality
   To what extent will air quality be improved (+) or degraded (-)?

6. Sensory quality of the environment
   To what extent will the sensory quality of the environment be improved (+) or degraded (-)?

7. Residential land-use
   To what extent will residential land-use be enhanced (+) or damaged (-)?

8. Commercial and Industrial land-use
   To what extent will commercial and industrial land-use be enhanced (+) or damaged (-)?

9. Agricultural land-use
   To what extent will agricultural land-use be enhanced (+) or damaged (-)?

10. Recreation and open space
    To what extent will recreation and open space land be enhanced (+) or diminished (-)?

11. Soil quality
    To what extent will agricultural and mechanical properties of the soil be improved (+) or damaged (-)?

12. Mineral resources
    To what extent will availability and quality of mineral resources be improved (+) or damaged (-)?

13. Energy
To what extent will the supply of energy be increased (+) or decreased (-)?

14. Access
To what extent is access (transportation, communication and service) improved (+) or damaged (-)?

15. Biotic communities
To what extent are biotic communities enhanced (+) or damaged (-)?

16. Unique or rare things
To what extent are unique or rare things enhanced (+) or damaged (-)?

TABLE E-II-3

CHECKLIST VECTOR E
PRIMARY IMPACT DIMENSIONS

1. Surface Water Quality

Sensory: taste, odor, color, turbidity, suspended and floating matter, algae, oil and grease, phenols, temperature;

Nutrients: phosphorus, nitrate nitrogen, total organic nitrogen, carbon (TOC, COD, BOD), dissolved oxygen;

Mineral content: pH, alkalinity, hardness, trace elements, salts, gaseous products, accumulated residues;

Health aspects: total coliform, fecal coliform, fecal streptococci, protozoa, insects and insect larvae, toxic substances (including pesticides and herbicides), radioactive substances.

2. Surface Water Quantity

dilution water; water supply: municipal, agricultural, industrial, recreational; water supply storage; flooding; sediments: erosion, deposition, transportation; navigation; lake levels; hydroelectric; spatial distribution, temporal distribution.

3. Subsurface Water Quality

see surface water quality

4. Subsurface Water Quantity

water supply: municipal wells, private wells; ground water recharge: confined and unconfined aquifers.

5. Air Quality

gases: SO_2, SO_X; NO_2, NO_X, CO, CO_2; hydrocarbons, aldehydes.

particles: nonviable: aerosols, mists, dust, smoke; viable: pollen grains; micro-organisms: algae, fungi, molds, yeasts, smuts, rust, spores, bacteria.

climate: atmospheric moisture (humidity, cloud cover, fog, precipitation) temperature, wind.

6. Sensory Quality of Environment

noise, odors, visual, irritants.

7. Residential Land Use.

8. Commercial and Industrial Land Use.

9. Agricultural Land Use.

10. Recreation and Open Space.

11. Soil Quality

fertility, infiltration capacity, moisture content, clay content, clay mineral composition, engineering properties (liquidity index, activity index, load bearing capacity);

trace elements, salts, surface cover, stability factors under stresses of development and natural weathering; mass movement and erosion processes;

slope factors, soil biota.

12. Mineral Resources (all phases excluding water resources)

reclamation from processes, coal, natural gas, liquid petroleum gas, nonmetallic mineral resources (crushed stone and aggregate, specialty sands, sand and gravel, gravel, high magnesium dolomite, high calcium dolomite, lightweight aggregate, gypsum, ceramic clays, dimension stone (limestone, dolomite).

13. Energy (Relative to available supply)

demand, production, consumption.

14. Changes of Access

transportation, communication, services (sewer service, water supply, etc.).

15. Biotic Communities (Quality as affected by changes in the quality of water, air, and soil as described above--e.g., eutrophication)

terrestrial communities (woodlands, grasslands, wetlands),
land plants (trees, shrubs, herbs, and grasses),
land animals (birds, mammals, reptiles, amphibibia, insects, etc.),
soil biota (fauna (macro-, ceso-, micro-) and flora),
dispersal (barriers, corridors);

aquatic communities (Lake Michigan, lakes, and ponds, and streams),
aquatic plants, phytoplankta, aquatic animals (zooplankta, insects,
crustacea, mollusca, fish (benthic biota, dispersal (barriers,
corridors).

16. Unique or Rare Things

cultural sites and artifacts (archaeological, historical); scientific sites (physical: features related to Pleistocene glaciation and relics of Lake Michigan development, Silurian reef structures (in quarries), Kentland dome, Indiana Dunes National Lakeshore: present area, proposed additions, terminal moraines, kettle lakes (many are now bogs), kames, eskers, or ice crevasse fillings, sand dunes associated with glacial Lake Chicago shorelines and the Kankakee outwash plain; ancestral Lake Michigan shoreline remnants, bedrock exposures of Silurian and Devonian carbonate rocks, Devonian Antrim shale and Pennsylvanian Mansfield sandstone; biological: organisms dependent upon certain habitats and/or with restricted ranges; endangered species: (ecosystems - characteristic of or unique to this area) scenic sites; unspoiled views; unusual land forms.

TRANSLATION OF PRIMARY IMPACTS INTO
HUMAN ACTIVITY IMPACTS (MATRIX B)

The primary impact parameters of the A matrix are significant largely to the extent that they enhance or detract from human activities, human health or ecosystem status. These impact areas were described in nineteen dimensions, collectively called the human activity impacts:

1. Commercial Production;
2. Industrial Production;
3. Food Production (Agriculture);
4. Construction Services;
5. Public Service;
6. Private Service;
7. Residential Activity;
8. Immigration (into C-SELM region);
9. Population Density Increase (shifts within C-SELM region);
10. Health and Safety;
11. Employment;
12. Income;
13. Cultural & Educational Activities;

TABLE [illegible]

A MATRIX RATING FORM

Judge: ______ (1,2)   System: ______ (3,4)   Element: ______ (5,6)

Primary Impact Category (Vector E)	Extremely Negative	Moderately Negative	Slightly Negative	Neutral	Slightly Positive	Moderately Positive	Extremely Positive	
				Magnitude of Change				
1. Surface Water Quality	-3	-2	-1	0	+1	+2	+3	(9,10)
2. Surface Water Quantity	-3	-2	-1	0	+1	+2	+3	(11,12)
3. Subsurface Water Quality	-3	-2	-1	0	+1	+2	+3	(13,14)
4. Subsurface Water Quantity	-3	-2	-1	0	+1	+2	+3	(15,16)
5. Air Quality	-3	-2	-1	0	+1	+2	+3	(17,18)
6. Sensory Quality of Environment	-3	-2	-1	0	+1	+2	+3	(19,20)
7. Residential Land Use	-3	-2	-1	0	+1	+2	+3	(21,22)
8. Commercial and Industrial Land Use	-3	-2	-1	0	+1	+2	+3	(23,24)
9. Agricultural Land Use	-3	-2	-1	0	+1	+2	+3	(25,26)
10. Recreation and Open Space	-3	-2	-1	0	+1	+2	+3	(27,28)
11. Soil Quality	-3	-2	-1	0	+1	+2	+3	(29,30)
12. Mineral Resources	-3	-2	-1	0	+1	+2	+3	(31,32)
13. Energy	-3	-2	-1	0	+1	+2	+3	(33,34)
14. Access	-3	-2	-1	0	+1	+2	+3	(35,36)
15. Biotic Communities	-3	-2	-1	0	+1	+2	+3	(37,38)
16. Unique or Rare Things	-3	-2	-1	0	+1	+2	+3	(39,40)

14. Public Finance;

15. Recreation;

16. Aesthetics of Area;

17. Ecosystem Status;

18. Community Political Structure;

19. Community Sociological Structure.

Again, a check list, Table E-II-5, is used to further describe the nineteen dimensions of human activity to the evaluators.

Matrix B traces the linkages and impacts of each primary impact dimension on each dimension of human activity. More particularly, it measures (as impact) the sensitivity of human activity to a positive change in each primary impact dimension. A human impact was considered to be positive if it increased, enhanced or reinforced the particular human activity; otherwise, it was negative. This sign convention is utilized merely for convenience and consistency, and does not reflect a judgment of preference.

TABLE E-II-5

CHECKLIST MATRIX B
HUMAN ACTIVITY DIMENSIONS

1. Commercial Production

Direct and external economies and diseconomies; services; local expenditures: materials and physical inputs; services, taxes, public service programs, etc.

2. Industrial Production

(see Commercial Production).

3. Food Production (Agriculture)

(see Commercial Production).

4. Construction

(see Commercial Production).

5. Public Services (services provided and local expenditures)

Local government: fire, health, recreation, transportation, power, water, waste treatment, education, safety, etc.;

County government: health, recreation, transportation, water, waste, sanitation, education;

State and Federal government: etc.

6. Private Services (services provided and local expenditures)

repair and maintenance, counseling, relocation, private utilities.

7. Residential Activity

Quality of the residential & neighborhood environment: crowding, amenity and aesthetic quality, social mix & stability, life style opportunities, access to & spectrum & quality of services & facilities;

Housing opportunity: spectrum of housing opportunity, quantity of supply, cost.

8. Immigration

Net migration to or from the geographic area. If immigration occurs, the impact is positive (+). If emigration, the impact is negative (-).

9. Population density

If increasing agglomeration of population occurs, the impact is positive (+). If dispersion is caused, the impact is negative (-).

10. Health and Safety

Incidence of specific diseases, incidence of accidents, utilization of services. Police and fire protection.

11. Employment

Supply and spectrum of opportunity, and unemployment, by relevant sectors; education level, skill, experience, sex, age, ethnicity.

12. Income

By relevant sectors: employment, profits, welfare, other; income distribution; level of affluence or poverty; disposable income.

13. Cultural/Educational Activities

Life styles (demands & consumption): demand for and consumption of education, consumption of material goods, consumption of non-material services, household goods, leisure goods; degree of social atomization, job search;

Availability and access to unique, cultural and scientific sites, facilities, etc. (supply);

Quantity & quality of formal educational opportunities (supply).

14. Public Finance

Local tax base; county tax base; state tax base.

15. Recreation

Quantity of opportunity; quality of opportunity; spatial distribution and accessibility;

Participatory: hiking, fishing, boating, swimming, camping, picnic, golf, hunting, skiing, skating, etc.

16. Aesthetics

General level of environmental pleasantness or amenity;

Specific aesthetic objects or sites: shopping areas, school developments, parking development, open space, scenic vistas & natural beauty, public buildings, public art & monuments, etc.;

Public attitude and concern; institutional attitude and concern.

17. Ecosystem Status

Ecosystem stability (succession, homeostasis), species diversity, food chains, productivity -eutrophication, biogeochemical cycling, concentration of toxic substances, disease aspects; vectors, alternative or intermediate hosts, introduction - invasions.

18. Community Structure

Rate these items in terms of the extent to which the proposed wastewater management system will reinforce (+) or undermine (-) the existing structure of the community. (The desirability or undesirability of such change is evaluated elsewhere.)

Political

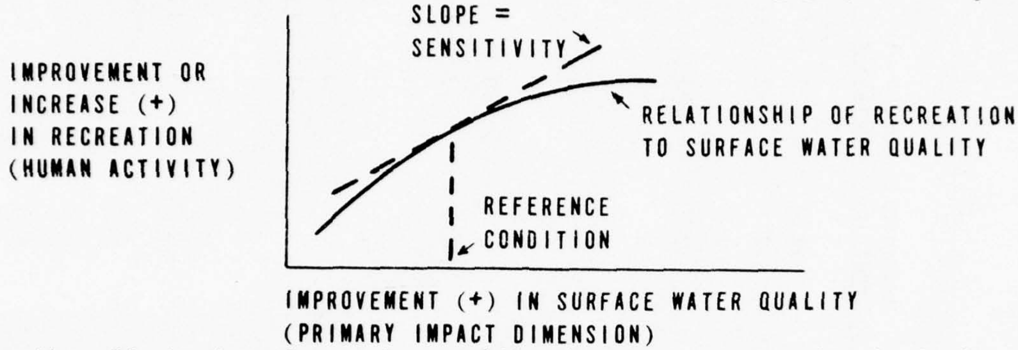
Social stratification, special purpose and interest groups, formal political role development, land use control, opposition or dissatisfaction.

Sociological

Services (material, social) agency development; family structure, rural to urban, rural to suburban, to metropolitan, world view; perceptions of social integration; racial, ethnic, class mix; neighborhood development; formal systems of control (e.g., police); antisocial behavior: crime, juvenile delinquency, vandalism, littering;

Community stability; quality of social interaction.

The concept employed is illustrated by the following graphic example.



Here the effect of surface water quality changes on recreation is depicted. The sensitivity of recreation to changes in surface water quality is represented by the slope of the curve at the reference surface water quality. In this case, an enhancement of surface water quality can be expected to enhance recreational activities. Hence, the slope of the relationship is positive. In the B matrix, the cell value describing this impact relationship would thus be positive, and its magnitude would describe the degree to which a "unit" enhancement of surface water quality would enhance recreation. For all of the evaluations, the reference point is present conditions. Again impacts are quantified on a scale of -3 to +3.

Unlike the Primary Impact Table (A Matrix), the Human Impact Table (B Matrix)as defined is not system element specific. To reiterate, the B matrix interprets the impact on environmental elements into the effect on human activities. The effect on human activities is system specific, but the relationship between environmental elements and human activities is not. As a consequence, the B matrix evaluations are not made in the context of a particular system. Indeed, relevant parts of the B matrix might be used to describe the effects on human activities brought about by environmental changes produced by a public highway system or a private building as well as to the wastewater management systems for which it was intended. To do so, directly, however, presumes that the evaluators were not imputing certain types of impacts likely to be associated with the systems under study. As intended, the B matrix simply describes the magnitude and direction of the phenomenological relationships between changes in the environment and changes in human activities, irrespective of the source of those changes. A sample of the form used by the evaluators is shown in Table E-II-6.

HUMAN ACTIVITIES IMPACTS OF SYSTEM ELEMENTS (C MATRIX)

Common to both the Primary Impact Table (A Matrix) and the Human Impact Table (B Matrix) is the vector of primary impact dimensions (E Vector). When the primary impacts of a particular system element (row of matrix A) are multiplied, each in turn, by the corresponding impact of each primary impact dimension on a particular human activity (column

TABLE E-II-6

B MATRIX RATING FORM

Judge: ___ ___ (1,2)   Primary Dimension (E): ___ ___ (3,4)

		Magnitude of Change							
		Extremely Negative	Moderately Negative	Slightly Negative	Neutral	Slightly Positive	Moderately Positive	Extremely Positive	
1.	Commercial Production	-3	-2	-1	0	+1	+2	+3	(9,10)
2.	Industrial Production	-3	-2	-1	0	+1	+2	+3	(11,12)
3.	Food Production	-3	-2	-1	0	+1	+2	+3	(13,14)
4.	Construction services	-3	-2	-1	0	+1	+2	+3	(15,16)
5.	Public service	-3	-2	-1	0	+1	+2	+3	(17,18)
6.	Private service	-3	-2	-1	0	+1	+2	+3	(19,20)
7.	Residential activity	-3	-2	-1	0	+1	+2	+3	(21,22)
8.	Immigration	-3	-2	-1	0	+1	+2	+3	(23,24)
9.	Population density	-3	-2	-1	0	+1	+2	+3	(25,26)
10.	Health and Safety	-3	-2	-1	0	+1	+2	+3	(27,28)
11.	Employment	-3	-2	-1	0	+1	+2	+3	(29,30)
12.	Income	-3	-2	-1	0	+1	+2	+3	(31,32)
13.	Cultural/Educational	-3	-2	-1	0	+1	+2	+3	(33,34)
14.	Public Finance	-3	-2	-1	0	+1	+2	+3	(35,36)
15.	Recreation	-3	-2	-1	0	+1	+2	+3	(37,38)
16.	Aesthetic	-3	-2	-1	0	+1	+2	+3	(39,40)
17.	Ecosystem Status	-3	-2	-1	0	+1	+2	+3	(41,42)
18.	Community Political Structure	-3	-2	-1	0	+1	+2	+3	(43,44)
19.	Community Social Structure	-3	-2	-1	0	+1	+2	+3	(45,46)

of matrix B) and the resulting products for all the primary impacts are summed, a total impact score of that system element, acting through all environmental changes, on that human dimension is produced. The System Element Impact Table (C Matrix) is the result of such an operation for all system elements and all human dimensions (mathematically, (A) x (B) = (C). It builds the relationship between the changes in system elements and the changes in human activities. The multiplications and summations are algebraic in their sign conventions (+ x + = +, + x - = - x +, - x - = +) so that impact directions are properly accounted for. In order to clarify how a negative (-) effect times a negative effect can be positive, the following example is offered: a negative effect (-) on air quality does in turn exert a negative effect (- discourages) on immigration to the C-SELM area, however, immigration is considered "bad" (-) by the evaluators, so the resultant effect is beneficial.

HUMAN ACTIVITIES WEIGHTS (H VECTOR)

The 19 human activities upon which the system element impacts impinge need not be ascribed to have equal importance in assessing total impact scores. Indeed, enhancement of some human activities may be viewed as having negative (undesirable) values. To represent the preferences for different activities, each evaluator was asked to assign a relative priority weight (again -3 to +3) to each human activity to reflect the desirability of enhancing or reinforcing the current condition of that activity relative to the other activities. A score of +3 for an activity indicates that it is extremely desirable to enhance or reinforce that activity, say health and safety, while a score of -2 indicates that it is moderately undesirable to reinforce that activity, say immigration to the C-SELM area. The weightings assigned by each evaluator were averaged for each activity to produce a human activity weighting scale. A sample of the form used by the evaluators to assign weights is shown as Table E-II-7.

It is important to recognize that these weightings can be determined or assigned by a group other than the evaluators themselves. In fact, a group of persons more experienced in deciding where public investments should be made to enhance human activities might be a preferred source of these priorities. As will be discussed later, a small number of weighting responses was obtained from each of two committees advisory to the Corps of Engineers on this project: one committee representing commercial and industrial representatives (6 responses) and another committee representing planning and sanitary district officials (4 responses). An average weighting vector was determined for each of these committees based on the responses supplied, and these weighting vectors were used in later analysis, along with a vector weighting all 19 human activities equally. (See Annex A.)

AGGREGATE SYSTEM EVALUATION

The Human Activities Impacts of System Elements (Matrix C) displays the impacts of each system element on each human activity. By multiplying each human activity impact by the human activity weight and summing the weighted impacts over all human activities, a total weighted impact for that system element is determined. The weighted impact score for a total system is then the sum of the weighted impacts for those system elements comprising the total system. Two or more systems utilizing the same

TABLE E-II-7

HUMAN FACTORS WEIGHTING FORM

Panelist ___ ___ (1,2)   Region ___ ___ (3,4)

Estimate the desirability of enhancing or reinforcing the following human factors in this region:

	Extremely Undesirable	Moderately Undesirable	Slightly Undesirable	Neutral	Slightly Desirable	Moderately Desirable	Extremely Desirable	
Commercial Production	-3	-2	-1	0	+1	+2	+3	(5,6)
Industrial Production	-3	-2	-1	0	+1	+2	+3	(7,8)
Food Production	-3	-2	-1	0	+1	+2	+3	(9,10)
Construction Services	-3	-2	-1	0	+1	+2	+3	(11,12)
Public Service	-3	-2	-1	0	+1	+2	+3	(13,14)
Private Service	-3	-2	-1	0	+1	+2	+3	(15,16)
Residential Activity	-3	-2	-1	0	+1	+2	+3	(17,18)
Population Migration	-3	-2	-1	0	+1	+2	+3	(19,20)
Population Density	-3	-2	-1	0	+1	+2	+3	(21,22)
Health and Safety	-3	-2	-1	0	+1	+2	+3	(23,24)
Employment	-3	-2	-1	0	+1	+2	+3	(25,26)
Income	-3	-2	-1	0	+1	+2	+3	(27,28)
Cultural/Education	-3	-2	-1	0	+1	+2	+3	(29,30)
Public Finance	-3	-2	-1	0	+1	+2	+3	(31,32)
Recreation	-3	-2	-1	0	+1	+2	+3	(33,34)
Aesthetics	-3	-2	-1	0	+1	+2	+3	(35,36)
Ecosystem Status	-3	-2	-1	0	+1	+2	+3	(37,38)
Community Political Structure	-3	-2	-1	0	+1	+2	+3	(39,40)
Community Sociological Structure	-3	-2	-1	0	+1	+2	+3	(41,42)

system element or module receive the same weighted impact score on that element when a system total impact score is calculated. This procedure insures a maximum degree of comparability in system impact scores and accents the differences in impacts among systems composed of different elements. This approach also highlights the elements of alternative systems which produce high or low scores, and thus can be of direct value to the design engineers in synthesizing new systems.

NARRATIVE DESCRIPTION OF IMPACTS

In the course of assessing impacts according to the matrix approach, each evaluator was encouraged to supplement his quantitative assessment by preparing written comments on the particular impact being considered. The comments were used to indicate the nature of the impact, especially where strongly positive or negative impact scores were involved. Evaluators were also encouraged to comment on any redesign opportunities for mitigation of negative impacts or enhancement of positive impacts which they identified.

Providing the evaluators with the opportunity to offer written comments also insured that issues and impacts which could not easily be treated in the context of the matrix evaluation scheme would still be included in the evaluation. In this way, maximum value could be derived from evaluators who were specialists in different disciplines; while the matrix approach forced a degree of uniformity on the evaluators' approaches, encouraging the preparation of detailed written comments allowed each expert to contribute to the process in a manner best suited to his own background and skills.

The comments of all evaluators were assembled and used to interpret the matrix scores. The comments were also woven together to form a narrative description of impacts. By this means, a more complete and, in many ways, more detailed assessment of impacts was obtained. This narrative is included in Section V of this report.

ILLUSTRATED APPLICATION

Use of the matrix approach to evaluation can be illustrated by the following examples:

> Example 1. The impact of the treatment facilities and processes element of the 33 plant physical-chemical treatment system on air quality (primary impact dimension) is perceived to be -1.6 units (A Matrix). The sensitivity of residential activity (human dimension) to an improvement in air quality (primary impact dimension) is perceived to be +2.2 (B Matrix). Thus the partial impact of the 33 plant physical-chemical process and facilities on residential activity due to the reduction in air quality is (-1.6) (+2.2) = (-3.5). The desirability of enhancing or reinforcing residential activity in the C-SELM area is +1.3 (weighting factor). Thus the

partial weighted impact of the 33 plant physical-chemical process and facilities as transmitted through air quality and residential activity is (-3.5) (1.3) = (-4.5), a negative impact. The maximum score could have been ($\pm$3) ($\pm$3) ($\pm$3) = ($\pm$27).

Example 2. The impact of the process and facilities element of the 33 plant physical-chemical process system on agricultural land use (primary impact dimension) is -0.1. The sensitivity of immigration (human activity) to an increase in agricultural land use is (-1.0) because agricultural land use does not provide residential or employment opportunities for large numbers of persons. The partial impact of the processes and facilities of the 33 plant physical-chemical system on immigration, then, is (-0.1) (-1.0) = (+0.1). The desirability of increasing immigration into the C-SELM area is perceived to be -1.5 (undesirable - from human activities weighting). Thus the partial weighted impact of the processes and facilities element of the 33 plant physical-chemical process system as transmitted through agricultural land use and immigration is (+0.1) (-1.5) = (-0.15), which means that the adoption of the physical-chemical treatment alternative would tend to reduce immigration to the C-SELM area slightly because of the impact on agricultural land use. It must be recognized that these numerical examples trace but single element linkages through the impact scoring system. The impact of a single system element on a single human activity is composed of the sum of the partial impacts transmitted through 16 primary impact dimensions. These sums are the values recorded in the C matrix. Likewise, the aggregate weighted impact of a single system element is the sum of the partial impacts imputed to each of the 19 human activities. Finally, each system is composed of 6 system elements, one from each of the major functional components, and the total weighted system score is the sum of the scores of its system elements.

LIMITATIONS OF THE EVALUATION METHODOLOGY

The matrix-based evaluation procedure described above is not designed to serve as an infallible decision rule, but rather as an informative technique for making the best possible use of the subjective judgments of experts by making those judgments explicit, quantifying them, aggregating and displaying them to identify the relative merits of wastewater treatment elements and systems. The results of the use of this approach should be utilized along with other kinds of information, such as economic feasibility and cost-benefit analyses, and technical feasibility studies, to assist the decision makers in the C-SELM region in their choice of the most desirable alternative system. The matrix evaluation methodology is designed to identify specifically the relative advantages and disadvantages of the various system elements, and to more fully describe the impact processes, so that the design engineers can synthesize more desirable systems. In any case, the scores produced for each alternative sytem should not be used as the sole means for the choice of the best alternative.

This evaluation procedure is built on the assumption that the judgments of well-informed experts are both meaningful and reliable and, furthermore, that the aggregation of the judgments of many experts provides a better estimate than the evaluation of one expert. While the use of theoretically-based mathematical models to predict the impacts of the proposed wastewater treatment alternatives might offer a more sophisticated approach to this problem, limitations of the state-of-the-art prohibit the implementation of this strategy. Studies in many other fields, however, tend to support the validity of the use of expert judgments in technical estimation problems of this type. In fact, given the nature of the problem, it is likely that expert judgment will produce results which are broader in focus, and more sensitive to the most relevant social and environmental issues, when compared to the use of mathematical models. Furthermore, the use of expert judgment is certainly to be preferred on a cost-effectiveness basis.

The validity of the judgment of experts is, of course, limited by the quality of the information provided to them as a basis for their evaluations. For example, each evaluator was instructed to assume that all descriptions of the performance characteristics of proposed systems, and all estimates of impacts, were accurate. To the extent that these descriptions and estimates are subject to errors, the judgments themselves are likely to be incorrect. The same implication holds for the effect of missing information, and absence of details. The latter factors can introduce unknown biases into the outcome of the process, and, as a result, it is of essential importance to provide the evaluators with the best possible information about the alternatives. On the other hand, caution must be used to avoid overloading the evaluators with too much information, which can have the effect of limiting their ability to make distinctions between alternatives. It has been found, for example, that asking the evaluators to treat a very large number of similar alternative systems can cause confusion and reduce the validity of the results. The use of a modular approach to evaluation, in which judges examine only a few elements of various types which can be combined into many alternative systems, serves to reduce this threat to validity of the results.

The matrix approach also assumes the independence of the effects of system elements from each other, the independence of primary environmental impacts, and the independence of human activities. For example, this assumption makes it possible to add the total human impact scores for several elements to produce a system score, without the danger of double counting. While the various rows and columns in the matrices, and the matrices themselves, were designed to minimize the effect of this assumption, care was taken to caution each evaluator about it, so that the individual judgments would be as independent as possible. The complexity of the true relationships which underlie the impacts evaluated with this system make it practically impossible to insure complete independence in all dimensions. However, given the characteristics of alternative methods, and the care taken in the application of this approach and the utilization of its outputs, the dangers of this assumption do not seem to be so serious.

Finally, the matrix method assumes that the changes being evaluated are relatively small, so that, for example, constant values could be used in the B matrix rather than impossible complex functional values. This assumption is particularly troublesome if large changes could induce a change in direction (from positive to negative, say) of impact. While the scale of the wastewater treatment alternatives to be evaluated in this effort is very large, the nature of the changes themselves can generally be safely assumed to be fairly small (in totality), at least in terms of the change that might be measured in some small portion of the region. The evaluation scheme is designed to aggregate many small changes, rather than to measure a few large scale changes.

SECTION III: PRIMARY IMPACTS OF ALTERNATIVE SYSTEMS

The first link in the impact chain connects each of the system elements, and thereby the systems or alternatives, to each of the primary impact dimensions. It is here that the quantitative social-environmental impacts of the systems are most clearly expressed. Subsequent linkages serve principally to allocate the impacts discerned at this stage among the multiple facets of human activity and to determine the extent to which these primary impacts affect the conduct of human affairs. Recognize, however, that the impacts reported reflect the average for the total C-SELM region, not the localized impact at any one point.

PRIMARY IMPACT TABLE (A MATRIX)

The average primary impact scores are first reported in Table E-III-1 in the form of the operational A matrix: that is, an average impact score is shown in each of the 16 primary impact dimensions for each of the 26 system elements. The value reported is the average of the impact scores ascribed by each evaluation team member. System elements are arranged vertically while primary impact dimensions are arrayed horizontally. Thus, each row of the table represents the primary impacts of one system element. Positive scores represent an increase or enhancement; negative scores, a decrease or repression.

System elements 1, 6, 11, 17, 22, and 24 are the components of alternative I (system 1), the 64 plant reference system. (Brief descriptions of the elements are shown in Table E-III-1). As such, its impacts were arbitrarily set to 0.0 and the impacts of all other systems were evaluated relative to those of system 1.

In scrutinizing the scores in the impact table, recall that each system element represents a collection of many individual components such as pipe lines, pumps, storage reservoirs, treatment plants, etc. Also, each primary impact dimension is a categorical name for many individual factors. An individual evaluator, in assessing impact perceived according to his special capabilities and insights, may scrutinize only a few of the many factors grouped within a single dimension or element. The impact score obtained by averaging over all evaluators thus represents the best overall assessment of impact for a particular element and dimension. Yet it is perilous to attempt to explain in works the reason or causal relationships that produced a particular average score. Such explanations are likely to be superficial at best. It is useful, however, to discuss some general characteristics of the primary impact matrix. The discussion, based upon the cell values and the row (system element) sums in Table E-III-1, is organized according to the 6 major categories of system elements.

TABLE E-III-I
PRIMARY IMPACT TABLE
AVERAGE A MATRIX

PRIMARY IMPACT DIMENSIONS

	Row Sum		System Element	1 Surface Water Quality	2 Surface Water Quantity	3 Ground Water Quality	4 Ground Water Quantity	5 Air Quality	6 Sensory Quality	7 Residential Land Use	8 Comm. & Ind. Land Use	9 Agricultural Land Use	10 Recreation & Open Space	11 Soil Quality	12 Mineral Resources	13 Energy	14 Access	15 Biotic Communities	16 Unique or Rare Things
1	0.0	Collection	64 Plant	-0.0	-0.0	-0.0	-0.0	-0.0	-0.0	-0.0	-0.0	-0.0	-0.0	-0.0	-0.0	-0.0	-0.0	-0.0	-0.0
2	2.4		33 Plant	.9	1.5	.2	.3	-.2	.7	.1	.1	-.5	.8	.2	-.2	-.8	-.2	-.2	-.3
3	1.3		17 Plant	.8	1.2	0.0	.1	-.2	.7	.2	.2	-.5	.9	.2	-.2	-1.0	-.5	-.2	-.4
4	-1.3		Land	.8	1.3	0.0	.3	-.2	.3	-.8	-.3	-.4	.8	.2	.1	-1.7	-.8	-.5	-.6
5	1.1		5 Plant + Land	1.0	1.5	.2	.4	-.1	.3	-.4	.1	-.2	1.0	.2	0.0	-1.4	-.5	-.5	-.5
6	0.0	Treatment	64 Plant CB	-0.0	-0.0	-0.0	-0.0	-0.0	-0.0	-0.0	-0.0	-0.0	-0.0	-0.0	-0.0	-0.0	-0.0	-0.0	-0.0
7	-6.5		33 Plant PC	.7	.2	.4	.2	-1.6	-1.4	-.2	.2	-.1	-.2	-.2	-1.7	-2.2	.3	-.7	-.2
8	0.1		17 Plant AB	1.0	.5	.7	.3	-.2	.1	-.2	-.4	.2	-.1	.2	-.3	-1.4	.1	-.2	-.2
9	-4.4		Land	.8	.5	-.5	.4	.2	-.5	-.9	-.6	-.5	.2	.1	.5	-1.5	-1.0	-.8	-.8
10	-2.3		5 Plant + Land	.7	.5	-.1	.3	-.2	-.4	-.4	-.5	-.2	.5	.2	-.2	-1.4	-.6	-.2	-.5
11	0.0	Sludge	Ag/CB	-0.0	-0.0	-0.0	-0.0	-0.0	-0.0	-0.0	-0.0	-0.0	-0.0	-0.0	-0.0	-0.0	-0.0	-0.0	-0.0
12	-6.6		Ag/PC	-.3	-.1	-.5	0.0	-.3	-.7	-.8	-.2	-.2	-.2	-.3	-.3	-1.2	-.5	-.7	-.3
13	1.4		Ag/AB	.2	.1	.1	-.1	0.0	-.1	-.4	-.2	1.2	.2	1.1	.3	-.5	-.2	-.1	-.2
14	0.8		Ag/Land	-.2	.2	-.2	.2	.1	0.0	-.5	-.1	1.0	.1	.8	.4	-.3	-.2	-.2	-.3
15	0.5		Ag/AB + Land	.1	.2	-.1	.2	0.0	-.1	-.3	-.2	.9	-.2	1.0	.2	-.4	-.3	-.1	-.2
16	8.0		Land Reclaim	.5	.1	.4	.1	.5	1.5	.9	.3	.8	1.7	1.2	.5	-1.1	.1	.5	0.0
17	0.0	Effluent	Nav-Rec/64	-0.0	-0.0	-0.0	-0.0	-0.0	-0.0	-0.0	-0.0	-0.0	-0.0	-0.0	-0.0	-0.0	-0.0	-0.0	-0.0
18	6.2		Nav-Rec/33	1.2	1.0	.5	.5	.1	.8	.5	.3	0.0	1.5	.2	-.2	-.8	.1	.4	.1
19	3.9		Nav-Rec/17	1.2	.9	.5	.5	0.0	.7	.4	.3	-.1	1.0	.1	-.5	-1.2	-.1	.3	-.1
20	1.9		Nav-Rec/Land	1.1	.8	.2	.6	-.1	.9	.2	-.2	-.2	1.1	.2	-.5	-2.0	-.4	.4	-.2
21	1.1		Nac-Rec/AB + Land	1.1	1.0	.4	.7	0.0	.9	.3	-.2	0.0	1.3	.2	-.4	-1.5	-.3	.5	-.2
22	0.0	Pot.	All From Lake M.	-0.0	-0.0	-0.0	-0.0	-0.0	-0.0	-0.0	-0.0	-0.0	-0.0	-0.0	-0.0	-0.0	-0.0	-0.0	-0.0
23	1.6		Reuse	-.1	.4	-.1	.3	.1	-.2	.1	.2	0.0	.4	-.1	.2	-.2	.2	.2	.2
24	0.0	Power	Power/64	-0.0	-0.0	-0.0	-0.0	-0.0	0.0	-0.0	-0.0	-0.0	-0.0	-0.0	-0.0	-0.0	-0.0	-0.0	-0.0
25	4.5		Power/Land	.5	-.1	0.0	.1	-.1	.2	.4	1.0	.5	.2	.3	.2	1.5	-.2	0.0	0.0
26	3.5		Power/AB + Land	.4	.2	.1	.2	-.1	-.1	.3	.6	.3	.1	.2	[illegible]	1.3	-.1	0.0	-.1

COLLECTION, TRANSPORTATION AND STORAGE:

Elements 2 through 5 all involve the collection, storage, and treatment of essentially all of the storm water runoff in the C-SELM region, a vast increase over that provided in the reference system (element 1). As such, these elements were judged to bring about substantial improvements in surface water quality and quantity (the latter through the capability of the system to control stream flows). Sensory quality of the environment was expected to be enhanced, as was recreation and open space, while the evaluators estimated that agricultural land use would be diminished or degraded somewhat as a result of the farm land utilized for the stormwater treatment facilities.

Major negative impacts were ascribed for energy and access as a result of the pumping and piping required to transport the water from one area to another. The negative impacts ascribed in these areas increase in accordance with the complexity of the water conveyance network required (element 2 is least complex, element 4 is most complex.)

TREATMENT FACILITIES AND PROCESSES:

By far, the majority of the impact scores were negative, as would be anticipated. The negative scores reflect the consumption of land, energy and mineral resources in the construction and operation of "factories" that degraded sensory and aesthetic qualities in their vicinity, produced air pollution, and impeded access. The physical-chemical treatment plant systems produced especially negative scores in air and sensory qualities and in energy and mineral resources, although a substantial negative impact was ascribed to all system elements with regard to energy. System elements 9 and 10, involving land treatment processes, produced substantial negative impact scores in all land use categories as well as access. All systems were assigned negative impacts on biotic communities. Small negative impacts are ascribed to system elements 7 through 10 in comparison to the reference system. Groundwater quality also was expected to improve somewhat except in those systems utilizing land treatment, where negative impacts were assessed due to the intermixing of the treated water with local groundwater. Modest positive impacts were assessed for surface and groundwater quality.

It is interesting to note, however, that the land treatment systems were attributed to produce small positive impact on recreation and open space, soil quality and, for the total land process, mineral resources.

SLUDGE MANAGEMENT:

System element 12, the agricultural application of sludge from physical chemical plants, was judged to yield negative impacts in all of the primary impact dimensions except groundwater quantity (where its impact was 0). Its most negative impact score was on energy, due in large measure to the requirements for transporting and distributing sludge to vast areas of farm lands. Other dimensions of substantial negative impact for this

element were groundwater quality, sensory quality, residential land use, access, and biotic communities. The PC sludge, indeed, was viewed as providing no beneficial characteristics.

Elements 13 through 15 involve the application of biological sludge to agricultural land. For these elements, substantial positive impacts were assigned to the dimensions of agricultural land use and soil quality, reflecting the generally beneficial characteristic ascribed to this type of sludge. Other impacts were generally a mixture of small negative and positive scores.

Element 16 represents the application of biological sludges to land reclamation areas. Substantial positive impacts were ascribed to this element in the dimensions of sensory quality, residential land use, agricultural land use, recreation and open space, and soil quality. The only negative impact, but a sizeable one, was ascribed to the energy needed to transport the sludge to the reclamation areas. In general, the land reclamation technique yielded impacts that reflected the substantial improvement in appearance and utility of strip-mined areas which could result from such a technique.

LIQUID EFFLUENT QUALITY AND DISTRIBUTION FOR NAVIGATION AND RECREATION:

The major impacts of the wastewater management systems on the water resources of the region were transmitted through this category. As a result, most of the impacts were evaluated as positive, most strongly in the dimensions of surface water quality and quantity, sensory quality of the environment, and recreation and open space. Negative impacts were ascribed to energy required to transport the water, mineral resources consumed in constructing the conveyance network, and access (because of disruption during construction). Variations among system elements reflect the complexity of the conveyance system needed to distribute the water around the region.

POTABLE WATER SUPPLY AND REUSE

The evaluation of water reuse (element 23) to make up deficiencies in available water supplies as needed to satisfy demand for potable water sources was ascribed to produce a mixture of small positive and negative impacts that, on balance, turn out to be slightly positive relative to the use of additional water from Lake Michigan (element 22).

POWER SYNERGISM

The evaluation of the power synergism reflects the impacts of siting power plants within the land treatment areas (elements 25 and 26) in comparison to siting them elsewhere in the C-SELM region. The assumption was made that power generation capability adequate to meet future needs would be built within the region, so that the choice was one of where best to locate stations rather than whether to build them in the area at all. The impact assessments clearly favor the use of the land treatment

sites, when available, with large positive impacts ascribed to surface water quality, commercial and industrial land use, and energy for both elements 25 and 26. However, the positive impacts ascribed to the alternative utilizing both treatment plants and land disposal were generally smaller than those attributed to the total land system.

TOTAL SYSTEM IMPACTS IN THE PRIMARY DIMENSIONS

The array of system element impacts presented in Table E-III-1 can be further combined to reveal the impact of a complete system in each primary dimension. This is accomplished by summing the impact estimates in each dimension indicated for that set of system elements comprising a single system. It implies, of course, that all impact dimensions are of equal importance. The systems and their system elements were described in Table E-II-2. The results of such an analysis are displayed in Table E-III-2.

The rows of Table E-III-2 are organized according to wastewater management alternative (I to V) and within alternative by system number according to type of sludge disposal and then according to potable water supply provisions. The dimensions of primary impact are ordered so as to place those with the most positive impact on the left side of the table and those with the most negative impacts on the right side.

As an illustration of the calculations involved, the impact on recreation and open space (first column) attributed to system 3 (second row) is composed of elements 2, 7, 12, 18, 23, and 24 of Table E-III-1, column 10. The total score is 0.8 - 0.2 - + 1.5 + 0.4 = 2.3.

Careful examination of the table will show that all systems are expected to produce substantial positive impacts on recreation and open space, surface water quality and quantity, groundwater quality and quantity. All systems except type II (physical-chemical) are expected to yield positive impacts on soil quality and sensory quality. A minor positive effect on groundwater quality is common to all systems except type IV (distributed land) with agricultural disposal of sludge.

Agricultural land use, mineral resources, commercial and industrial land use, and air quality are all characterized by a mixture of weakly positive and negative impact scores, with the exception that the type II (P.C.) alternatives are evaluated as strongly negative on mineral resources and air quality. Biotic communities and residential land use are judged to be negatively impacted by all system except Type III (17 plant AB) and Type V (AB + land) with sludge disposed by land reclamation. All other dimensions, and especially energy, are negatively impacted by all systems.

TABLE E-III-2

TOTAL SYSTEM IMPACTS IN THE PRIMARY DIMENSIONS[1]

System Type	System Number	Sludge Management	Potable Supply	Power	Recreation & Open Space	Surface Water Quality	Surface Water Quantity	Groundwater Quantity	Soil Quality	Sensory Quality	Groundwater Quality	Agricultural Land-Use	Mineral Resources	Comm. & Ind. Land Use	Air Quality	Biotic Communities	Residential Land-Use	Unique or Rare Things	Access	Energy	System Score (Row Sum)
					10	1	2	4	11	6	3	9	12	8	5	15	7	16	14	13	
I-Ref	1	Ag.	L.M.		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
II-R.C.	3	Ag.	Reuse		2.3	2.4	3.0	1.3	-0.2	-0.8	0.5	-0.8	-2.2	0.6	-1.9	-1.0	-0.3	-0.5	-0.1	-5.2	-2.9
	2	Ag.	L.M.		1.9	2.5	2.6	1.0	-0.1	-0.6	0.6	-0.8	-2.4	0.4	-2.0	-1.0	-0.4	-0.7	-0.3	-5.0	-4.5
III-A.B.	7	Land	Reuse		3.9	3.4	3.1	1.3	1.6	2.8	1.5	0.4	-0.3	0.6	0.2	0.6	1.4	-0.5	-0.2	-4.9	14.9
	6	Land	L.M.		3.5	3.5	2.7	1.2	1.7	3.0	1.6	0.4	-0.5	0.4	0.1	0.4	1.3	-0.7	-0.4	-4.7	13.3
	5	Ag.	Reuse		2.4	3.1	3.1	1.1	1.5	1.2	1.2	0.8	-0.5	0.1	-0.3	0	0.1	-0.7	-0.5	-4.3	8.3
	4	Ag.	L.M.		2.0	3.2	2.7	0.8	1.6	1.4	1.3	0.8	-0.7	-0.1	-0.4	-0.2	0	-0.9	-0.7	-4.1	6.7
IV Land	14	Land	Reuse	Yes	4.4	3.6	3.0	1.8	1.9	2.4	0	0.2	1.0	0.4	0.4	-0.2	-0.1	-1.4	-2.1	-5.0	10.3
	15	Land	L.M.	Yes	4.0	3.7	2.6	1.5	2.0	2.6	0.1	0.2	0.8	0.2	0.3	-0.4	-0.2	-1.6	-2.3	-4.8	8.7
	12	Land	Reuse		4.2	3.1	3.1	1.7	1.6	2.2	0	-0.3	0.8	-0.6	0.5	-0.2	-0.5	-1.4	-1.9	-6.5	5.8
	13	Land	L.M.		3.8	3.2	2.7	1.4	1.7	2.4	0.1	-0.3	0.6	-0.8	0.4	-0.4	-0.6	-1.6	-2.1	-6.3	4.2
	11	Ag.	Reuse	Yes	2.8	2.9	3.1	1.9	1.5	0.9	-0.6	0.4	0.9	0	0	-0.9	-1.5	-1.7	-2.4	-4.3	3.1
	10	Ag.	L.M.	Yes	2.4	3.0	2.7	1.6	1.6	1.1	-0.5	0.4	0.7	-0.2	-0.1	-1.1	-1.6	-1.9	-2.6	-4.0	1.5
	9	Ag.	Reuse		2.6	2.4	3.2	1.8	1.2	0.7	-0.6	-0.1	0.7	-1.0	0.1	-0.9	-1.9	-1.7	-2.2	-5.7	-1.4
	8	Ag.	L.M.		2.2	2.5	2.8	1.5	1.3	0.9	-0.5	-0.1	0.5	-1.2	0	-1.1	-2.0	-1.9	-2.4	-5.5	-3.0
V Land + A.B.	23	Land	Reuse	Yes	5.0	3.6	3.7	2.2	1.9	2.0	0.9	0.7	0.3	0.5	0.2	0.5	0.8	-1.1	-1.2	-4.3	15.7
	22	Land	L.M.	Yes	4.6	3.7	3.3	1.9	2.0	2.2	1.0	0.7	0.1	0.3	0.1	0.3	0.7	-1.3	-1.4	-4.1	14.1
	21	Land	Reuse		4.9	3.2	3.5	2.0	1.7	2.1	0.8	0.4	0.1	-0.1	0.3	0.5	0.5	-1.0	-1.1	-5.6	12.2
	20	Land	L.M.		4.5	3.3	3.1	1.7	1.8	2.3	0.9	0.4	-0.1	-0.3	0.2	0.3	0.4	-1.2	-1.3	-5.4	10.6
	19	Ag.	Reuse	Yes	3.1	3.2	3.8	2.3	1.7	0.4	0.4	0.8	0	0	-0.3	-0.1	-0.6	-1.3	-1.6	-3.6	8.2
	18	Ag.	L.M.	Yes	2.7	3.3	3.4	2.0	1.8	0.6	0.5	0.8	-0.2	-0.2	-0.4	-0.3	-0.7	-1.5	-1.8	-3.4	6.6
	17	Ag.	Reuse		3.0	2.8	3.6	2.1	1.5	0.5	0.3	0.5	-0.2	-0.6	-0.2	-0.1	-0.9	-1.2	-1.5	-4.9	4.7
	16	Ag.	L.M.		2.6	2.9	3.2	1.8	1.6	0.7	0.4	0.5	-0.4	-0.8	-0.3	-0.3	-1.0	-1.4	-1.7	-4.7	3.1

1 - The positive (+) or negative (-) numbers presented on this table do not connote beneficial or detrimental (i.e. good or bad). These figures present subjective assessment of the direction and magnitude of change, without deciding whether that change is given a value of good or bad.

RANKING OF SYSTEMS ACCORDING TO PRIMARY IMPACT DIMENSIONS

A single impact score can be assigned to each system by summing the impacts for that system over all of the primary impact dimensions (sum across each row in Table E-III-2). These sums are shown as the far right hand column in Table E-III-2.

From the system scores produced by the judgements of the evaluation panel, it is apparent that the systems are arranged in descending order within alternative type, indicating that: land reclamation with sludge is consistently preferred to agricultural application of sludge; reuse for potable water supply is preferred to further use of additional Lake Michigan water; and power generation at the land disposal sites is preferred to other locations in the C-SELM region.

The four highest scoring systems are: 23 (Type V), 7 (Type III), 22 (Type V) and 6 (Type III). Both types rely heavily on use of advanced biological treatment plants. The two lowest scoring systems are 3 and 2 (Type II), the physical-chemical plants.

It should be noted that this simplified overview of the primary environmental impacts of the alternatives assumes that all changes in the social-environmental dimensions are of equal importance. The evaluation technique, however, was designed to go beyond this limited assessment to the evaluation of the consequences of these impacts for human activities. These effects are described in the following chapter.

SECTION IV: IMPACTS OF SYSTEM ELEMENTS ON HUMAN ACTIVITIES

SYSTEM ELEMENT IMPACT TABLE

The primary impacts of the wastewater management alternatives reported in Chapter III are allocated among the 19 dimensions of human activity through the application of the "B" matrix described in Section II and Annex A. This allocation also amplifies or contracts the impacts according to the sensitivity of each human dimension to each primary impact dimension. Thus, the impact score produced by a particular system element for a particular human activity is determined by multiplying the primary impact score of that system element in each primary dimension by the sensitivity of that human activity to each primary dimension and summing the products (with due regard to sign) over all of the primary dimensions. This process, when repeated for all system elements and all human activities, is in reality the multiplication of the A matrix by the B matrix. This multiplication produces the C matrix, a table of system element impacts on human activities. The results obtained by multiplying the average A matrix (Table E-III-1) by the average B matrix (Table EA-1 Annex A) are shown as Table E-IV-1. Each row represents the impacts of a particular system element on each of the 19 human activities. These impacts are discussed, by category, in the following paragraphs. A more complete discussion is contained in Section V of this report.

COLLECTION, TRANSPORTATION AND STORAGE

Strong positive impacts on health and safety, recreation, aesthetics, and ecosystem status were associated with the collection, transportation and storage elements of the systems treating virtually all of the storm water (II,III,IV and V). The systems utilizing treatment plants, either PC or AB, were also judged to produce strong positive impacts on residential activity and immigration, and weakly positive impacts on the remaining dimensions of human activity.

By contrast, the all-land treatment systems (Alternative IV) produced small to moderate negative impacts in all dimensions of human activity except recreation, aesthetics, ecosystem status, and health and safety, with the most negative impacts relating to production (except food), income and employment. The systems requiring the least complex collection and transportation networks tended uniformly to produce the most positive impacts.

TREATMENT PROCESSES AND FACILITIES

Only Alternative III (17 plant AB) shows any appreciable number of positive impacts, and then only in the dimensions of health and safety, ecosystem status, recreation, aesthetics, and food production. All other alternative systems were judged to produce substantially negative impacts in virtually all of the human dimensions. Interestingly, Alternative V, utilizing a combination of AB treatment plants and land treatment, was expected to produce impacts more closely related to the land treatment

TABLE E-IV-1
IMPACTS OF SYSTEM ELEMENTS ON HUMAN ACTIVITIES
C MATRIX (AVERAGE)

		SYSTEM ELEMENT	Commercial Production 1	Industrial Production 2	Food Production 3	Construction Services 4	Public Service 5	Private Service 6	Residential Activity 7	Immigration 8	Population Density 9	Health & Safety 10	Employment 11	Income 12	Cultural-Educat. 13	Public Finance 14	Recreation 15	Aesthetics 16	Ecosystem Status 17	Community Pol. Str. 18	Comm. Social Str. 19	ROW SUMS
1	Collection	64 Plant	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2		33 Plant	.4	.8	.6	.5	1.8	1.3	4.9	3.8	2.6	3.2	1.6	1.5	1.4	1.8	7.0	6.6	5.4	1.3	1.2	47.8
3		17 Plant	-.6	-.9	-.9	-.4	.9	.4	3.2	2.7	1.9	2.5	.6	.6	.7	.9	5.5	5.7	4.5	.8	.7	28.6
4		Land	-3.5	-2.5	-.8	-3.0	-1.6	-2.3	- .8	-.4	-.3	1.2	-2.4	-1.9	-1.6	-1.0	4.3	5.1	5.5	-.8	-.5	-7.3
5		5 Plant + Land	-.9	-.2	.7	-1.0	.4	-.1	2.1	1.7	1.0	2.5	.0	.1	-.2	.6	6.1	6.2	5.9	.1	.1	25.3
6	Treatment	64 Plant CB	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
7		33 Plant PC	-4.1	-6.1	-3.5	-5.2	-3.1	-3.2	-7.9	-6.0	-5.5	-5.9	-5.5	-4.9	-5.5	-4.2	-5.9	-6.8	-3.2	-3.3	-3.2	-93.1
8		17 Plant AB	-1.5	-2.3	2.5	-1.7	- .5	- .9	.6	- .3	- .9	1.8	-1.5	- .8	- .5	- .4	3.2	4.1	5.0	- .2	- .1	5.6
9		Land	-4.5	-2.4	-1.7	-3.5	-3.1	-3.8	-4.1	-2.9	-1.7	- .7	-3.9	-3.3	-3.9	-2.3	-1.3	- .2	1.4	-2.0	-1.4	-45.4
10		5 Plant + Land	-3.8	-3.6	- .6	-3.4	-2.0	-2.6	-2.2	-2.1	-1.7	.0	-3.4	-2.7	-2.0	-2.0	1.3	2.0	3.5	-1.4	- .8	-27.5
11	Sludge	Ag/CB	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
12		Ag/PC	-4.8	-4.3	-4.4	-4.6	-4.2	-4.2	-8.2	-5.7	-4.1	-4.9	-5.2	-4.8	-5.0	-4.0	-6.4	-5.8	-3.7	-3.0	-2.5	-90.1
13		Ag/AB	- .7	-1.6	5.4	- .6	- .9	- .8	-1.6	-2.0	-1.8	.6	-1.2	- .6	-1.0	-1.0	2.0	2.9	4.2	- .7	- .8	-0.3
14		Ag/Land	- .3	- .2	4.1	- .1	- .9	- .7	-1.7	-1.7	-1.5	- .3	- .8	- .5	-1.5	- .7	.6	1.2	2.2	- .8	- .9	-4.5
15		Ag/AB + Land	- .8	- .8	4.7	- .5	-1.2	-1.1	-1.9	-2.1	-1.9	- .2	-1.2	- .8	-1.5	- .9	.4	1.3	2.9	- .8	-1.0	-7.5
16		Land Reclaim	1.7	-2.3	4.8	1.9	2.9	2.9	7.9	5.3	3.1	7.1	2.6	3.1	5.2	2.5	11.8	13.4	11.1	2.9	2.6	90.5
17	Effluent	Nav-Rec/e4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
18		Nav-Rec/33	1.9	.2	2.5	1.2	3.4	2.9	8.0	5.6	3.4	6.3	2.9	3.0	4.9	2.9	11.8	11.8	9.8	2.5	2.3	87.5
19		Nav/Rec/17	.7	-1.2	1.4	-.1	2.0	1.5	5.7	3.8	2.0	4.9	1.4	1.6	2.9	1.7	8.8	9.4	8.2	1.6	1.4	57.8
20		Nav-Rec/Land	-2.7	-5.1	-.0	-2.8	-.0	-.7	3.1	1.8	.5	4.0	-1.7	-.8	2.0	-.2	8.6	10.2	9.7	.8	1.0	27.7
21		Nav-Rec/AB+L	-1.3	-3.2	1.6	-1.5	1.2	.5	5.4	3.3	1.6	5.3	-.1	.5	3.1	.9	10.5	11.7	10.7	1.4	1.6	53.4
22	Pot.	All from L.M.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
23		Reuse	1.0	1.2	.4	.9	1.1	1.1	1.4	1.2	.6	.4	1.0	.9	1.4	.6	2.3	1.7	1.4	.4	.4	19.6
24	Power	Power/6-4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
25		Power/Land	5.4	5.8	3.1	4.3	3.2	3.4	4.1	3.3	2.5	1.9	5.1	4.0	1.5	3.1	1.4	.2	-.6	1.3	.4	53.6
26		Power/AB+L	4.4	5.5	3.0	3.7	2.8	2.9	3.7	2.9	2.3	1.6	4.3	3.3	1.0	2.7	1.2	-.1	-.6	1.0	.4	45.9

system than to the treatment plant system, although to some degree the scores did reflect a combination of the two systems. The physical-chemical treatment system was expected to produce the most strongly negative impacts of all the alternatives.

SLUDGE MANAGEMENT

Strong positive impacts were ascribed to all of the human dimensions (except industrial production) for the use of biological sludges in land reclamation. The impacts were judged to be exceptionally strong for recreation, aesthetics and ecosystem status. In contrast to this, the application of physical-chemical sludges to agricultural land was regarded as producing substantial negative impacts in all dimensions of human activity, most strongly so for residential activity. The agricultural application of biological sludges was judged to have modest positive impacts on ecosystem status, aesthetics, recreation and food production but weakly negative impacts for the remaining dimensions of human activity.

EFFLUENT QUALITY AND DISTRIBUTION FOR NAVIGATION AND RECREATION

The expected positive impacts of the wastewater management alternatives on the water resources of the region are displayed more strongly here. Only the land treatment system was ascribed to produce numerous negative impacts in connection with the effluent redistribution to the region, generally in the dimensions of production (except food), income and employment. As was true for other system elements, the most positive impacts were associated with aesthetics, recreation, ecosystem status, residential activity and immigration. All systems were judged to produce substantial positive impacts in these categories, and the magnitude of impact corresponded directly to the extent of decentralization of treatment facilities (number of plants or sites) and the corresponding simplicity (brevity) of the conveyance networks required to distribute the effluent throughout the region.

POTABLE WATER SUPPLY AND REUSE

Small positive impacts were ascribed to all dimensions of human activity when deficiencies in potable water supply were met by the reuse of treatment effluents rather than drawing additional quantities of water from Lake Michigan.

POWER SYNERGISM

The siting of power generating facilities on land utilized for the land treatment systems was considered to produce small to moderate positive impacts in all of the human dimensions except ecosystem status, where very small negative impacts were assessed. The most positive impacts were associated with production, income, employment, public finance and residential activity. The impacts produced with the alternative V systems (5 plant plus land) were not as great as those for the alternative type IV systems (total land) because of less power at the smaller land sites associated with the type V alternative.

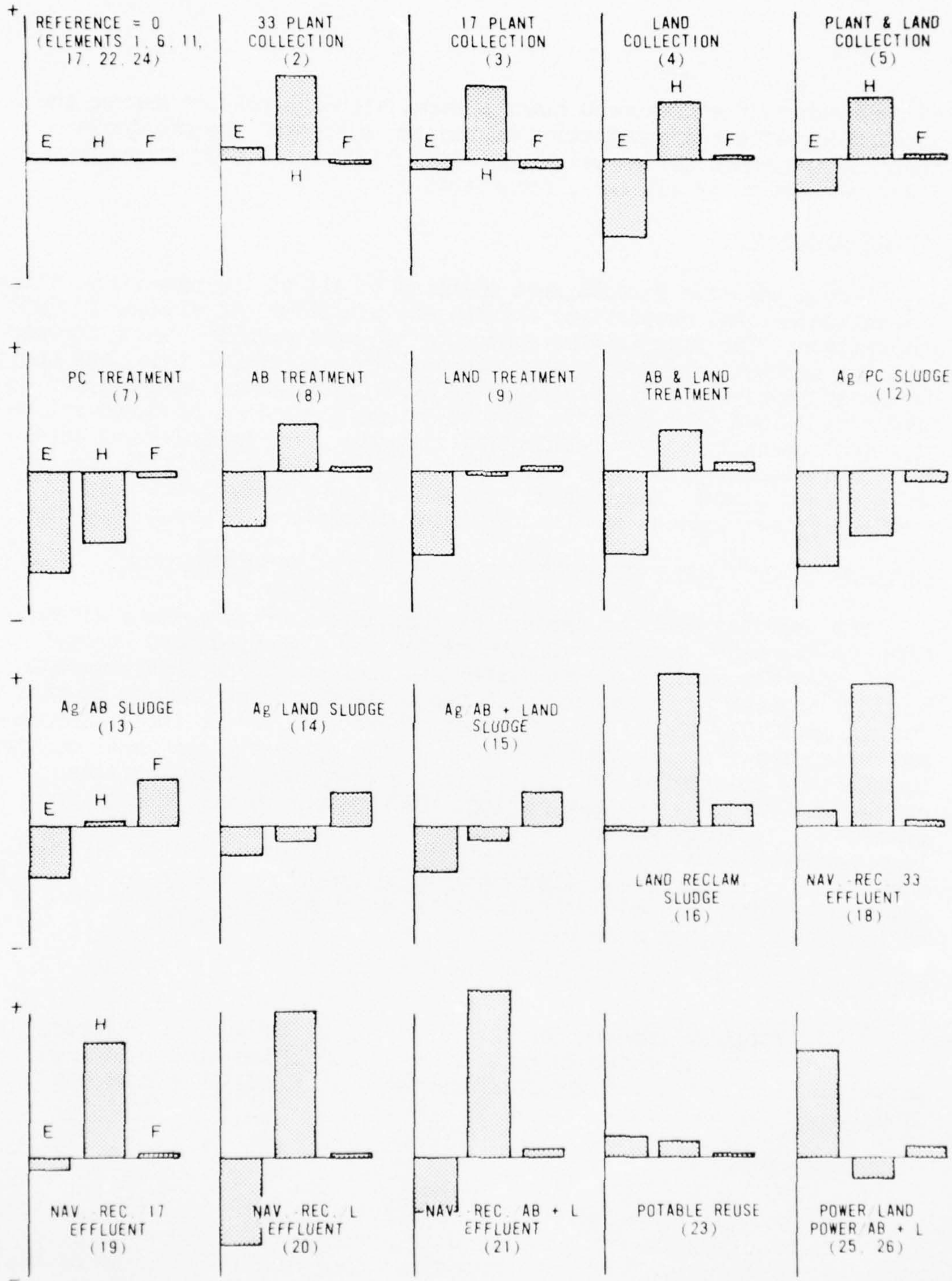


FIGURE E-IV-1

IMPACTS OF SYSTEM ELEMENTS IN THREE FUNDAMENTAL DIMENSIONS

E = ECONOMIC H = HUMAN F = FOOD PRODUCTION

FUNDAMENTAL DIMENSIONS OF HUMAN IMPACT

The impact scores recorded in the average C matrix were subjected to a factor analysis to determine whether the 19 dimensions of human activity could be combined in some way to yield a smaller number of dimensions without losing information about the total impacts involved.

The results of the factor analysis of the C matrix revealed that over 98% of the information in the matrix can be described by three fundamental dimensions. The first factor, representing 47% of the information, consists primarily of the following human activities: commercial production, industrial production, construction service, public service, private service, employment, income and public finance. It in a sense represents an economic dimension.

The second factor, representing 46% of the information, consists primarily of: residential activity, immigration, cultural-educational, health and safety, recreation, aesthetics, ecosystem status, community social structure, and community political structure. It may be regarded as the human-ecological dimensions or, more simply, the human dimension. Population density contributes equally to each of the two fundamental dimensions.

The third factor consists almost entirely of food production. It should be noted however, that all 19 of the original activities influence, to some extent, each of the three fundamental dimensions. The choice of which activities associate with which fundamental dimension was made on the basis that the particular activity contributed half or more of its information (numerical judgements) on that particular fundamental dimension.

Analysis of the impacts of system elements in terms of these three aggregate dimensions provides a simple approach to understanding some of the results described previously. The impacts of the individual system elements on each of the fundamental human activity dimensions (Economics, Human, Food Production) are shown graphically in Figure E-IV-1. All reference elements (the elements of Alternative I) were arbitrarily assigned a zero impact and are represented by the first graph. Elements 2 through 5, representing collection system functional category, all have strong positive impacts on the human factor and weak positive or negative impacts on the food production factor. Element 2 displays a weakly positive impact in the economic factor, while element 3 through 5 show negative impact in the economic factor, while elements 3 through 5 show negative impacts on the economic factor, most strongly for the land treatment system.

Elements 7,8,9 and 10 comprise the treatment processes and facilities category. None of the elements impact strongly on food production. PC treatment, element 7, is strongly negative in both the economic and human dimensions. Land treatment, element 9, is strongly negative in the economic dimension but only weakly negative in the human dimension. Elements 8 and 10, the AB alternative, produce strong negative impacts in the economic dimension but moderate positive impacts in the human dimension.

The impacts associated with the application of sludges to agricultural land are represented by elements 12 through 15. Element 12, the agricultural application of PC sludge, produces strongly negative impacts in the economic and human dimensions, and a weak negative impact on food production. Elements 14 and 15, where the sludge is taken from the land treatment or mixed land treatment plus AB treatment, produces small to moderate negative impacts on the economic and human dimensions and

moderate positive impacts on food production. Element 13, the agricultural application of AB sludge, produces a moderately negative economic impact, a small positive human impact and a moderately positive food production impact.

Element 16, the application of sludge for land reclamation, produced a slightly negative economic impact, an extremely positive human impact and a small positive food production impact.

Elements 18, 19, 20 and 21 reflect the distribution of effluents to the streams of the region for navigation and recreation. The dominant features worthy of note are the consistently strong positive impacts in the human dimension for all elements and the moderately negative impacts in the economic dimension for the two alternatives involving land treatment (elements 20 and 21).

Element 23, representing the reuse of effluent for supplying potable needs, is seen to produce small positive impacts in all dimensions.

Elements 25 and 26, reflecting power synergisms with the land systems, yielding strong positive impacts in the economic dimension, small positive impacts on food production, and small negative impacts on human activities.

Recall that while the economic and human dimensions contributed about equally to the total impact, the food production contributed much less. Thus, an implicit weighting of the three dimensions results. If each of the three dimensions are adjusted to weight equally in the total impact, the effect is to magnify the contribution of food production, while reducing the relative significance of the other dimensions. The three dimensional profiles for the system elements when all dimensions are equally weighted (unit weighting) are shown in Figure E-IV-2. One advantage for the unit weighting approach is that it facilitates the application of any other weighting system that might later be felt to be more appropriate, since the impact score in each dimension can be contracted or expanded by a simple multiplication by a weighting factor.

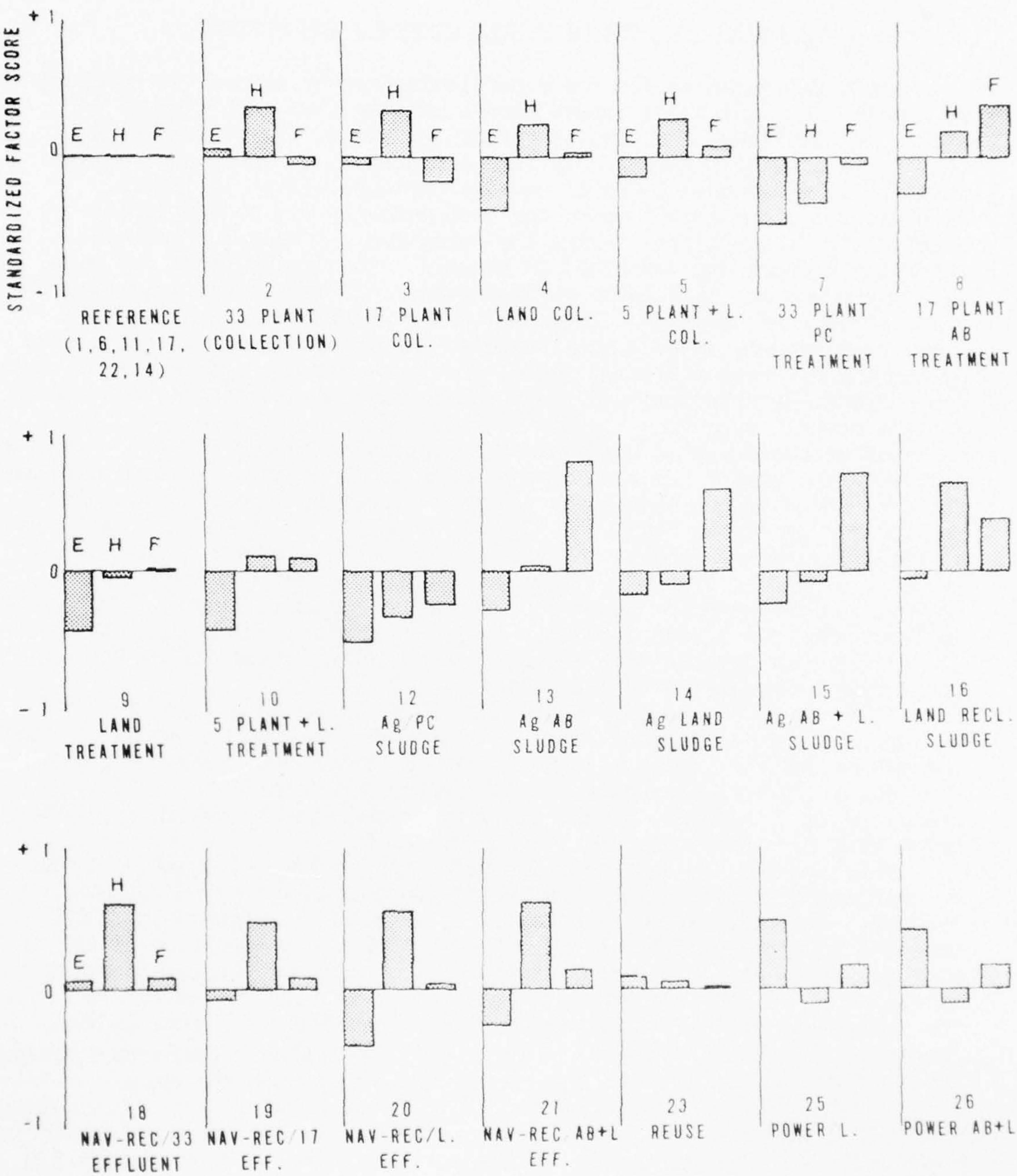


FIGURE E-IV-2

SYSTEM ELEMENT SCORES IN THREE FUNDAMENTAL DIMENSIONS

(DIMENSIONS EQUALLY WEIGHTED)

E = ECONOMIC　　H = HUMAN　　F = FOOD PRODUCTION

WEIGHTED IMPACTS OF SYSTEM ELEMENTS AND SYSTEMS

The total impact score for a particular system element is obtained by summing the individual impact scores arising from that element in each human activity; that is, by taking the sum of the scores in each row of the average C matrix. If such a procedure is used, each human activity is considered to be of equal importance vis-a-vis impact. Alternatively, the impact score for each activity may be multiplied by a weighting factor before taking the summation. A number of possible weighting vectors are described in Annex A. The impact score for each system element was calculated utilizing each of the several weighting vectors described earlier. The results are presented in Table E-IV-2. From these scores, total system weighted impact scores can be calculated by summing the system element scores for those elements comprising a system. System descriptions and the resulting system weighted impact scores for the several weighting vectors are presented in Table E-IV-3. The weighted scores are also displayed graphically in Figure E-IV-3, where the unit weighted scores are also displayed on the ordinate. Plotted also are the unweighted system scores as calculated from the A matrix alone (see section III and Table E-III-2). It can be seen that, generally, all systems score higher under the evaluators' priority scheme than under the unit weighting system. Yet is is also clear that the correlation between the two sets of system scores is very strongly linear. This implies that even if all impacts are valued equally, selecting the highest scoring systems will result in a choice which satisfies the evaluators' human activity priorities.

It can also be observed that in only two cases do alternative systems shift in their rank order of preference between the equal weighting scheme and the impact priorities of the evaluators. These are systems 8 and 12, both distributed land treatment alternatives. The change in rank, however, amounts only to an increase of two in the rank order list for system 12, and one for system 8.

This ignores the fact that the reference system, alternative I, has an evaluators' score which seems inconsistent with the scores of other systems. That is, system 1, which is alternative 1, appears to score somewhat lower than might be indicated through the application of the unit weighting scheme, or the weights of the other panels. This might be explained by the fact that the evaluators were instructed to fix the impacts of the reference system at the zero level. Figure E-IV-3 suggests that this assignment of zero score to **System I (Reference System)** was somewhat artificial, and that to be consistent with the evaluators' score of about 65.0. Giving System I a 65.0 rating would also necessitate adding 65.0 points to all other systems ratings, resulting in no change in overall system ranking. As it stands, the evaluators prefer systems 3,8, and 9 to the reference system; the former is a physical-chemical system, while the latter two are distributed land alternatives. This inconsistency, in any case, is of minor importance, since 18 systems are distinctly preferred to the reference system.

In Figure E-IV-3 the effect of the final evaluators' H vector may also be compared with the effect of the impact priorities prepared by the commercial/industrial panel. The evaluators can be seen to score

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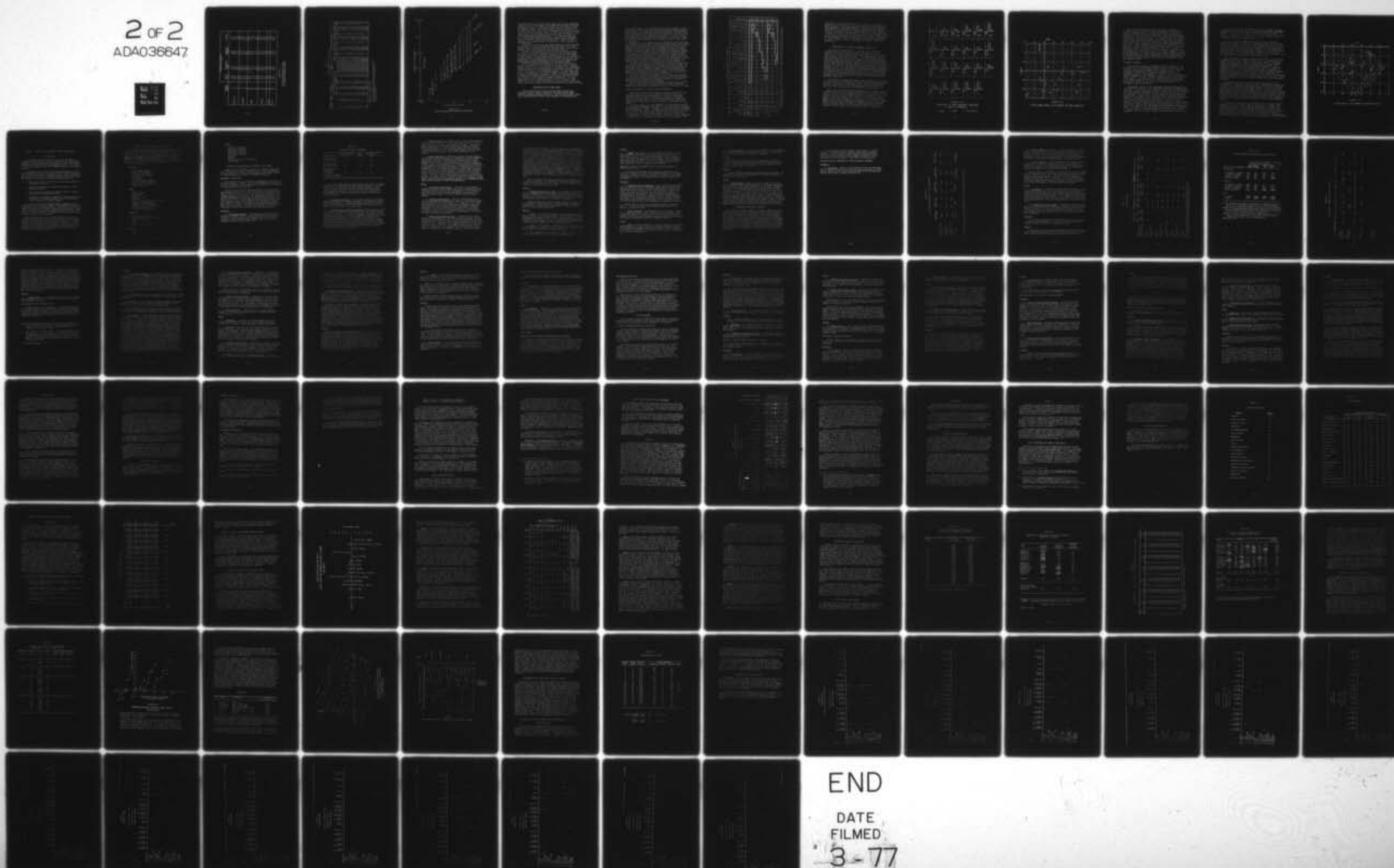

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		WEIGHTING CRITERION			
	SYSTEM ELEMENT	UNIT VECTOR	EVALUATORS (NEW)	COMMERCE & INDUSTRY	PLANNERS
	1	0.0	0.0	0.0	0.0
	2	47.8	76.5	35.8	50.7
Collection	3	28.6	49.6	18.0	33.7
	4	-7.3	9.2	-7.6	6.0
	5	25.3	52.5	21.5	32.8
	6	0.0	0.0	0.0	0.0
	7	-93.1	-125.8	-77.2	-82.0
Treatment	8	5.6	28.9	8.2	13.6
	9	-45.4	-56.3	-35.4	-31.6
	10	-27.5	-21.2	-23.3	-14.7
	11	0.0	0.0	0.0	0.0
	12	-90.1	-127.8	-75.6	-79.0
Sludge	13	-.3	23.1	10.9	3.6
	14	-4.5	6.7	6.3	-2.9
	15	-7.5	6.0	5.0	-4.7
	16	90.5	162.6	70.7	91.6
	17	0.0	0.0	0.0	0.0
	18	87.5	150.6	67.4	89.3
Effluent	19	57.8	106.1	43.9	62.2
	20	27.7	75.0	14.4	40.9
	21	53.4	111.4	37.8	63.7
	22	0.0	0.0	0.0	0.0
Potable	23	19.6	30.6	14.8	17.1
	24	0.0	0.0	0.0	0.0
Power	25	53.6	64.0	53.6	40.2
	26	45.9	53.0	46.4	35.0

TABLE E-IV-2

SYSTEM ELEMENT IMPACT SCORES
FOR SEVERAL WEIGHTING VECTORS

TABLE E-IV-3

SYSTEM DESCRIPTIONS AND IMPACT SCORES

SYSTEM NUMBER	SYSTEM TYPE *	SYSTEM DESCRIPTION				SYSTEM ELEMENTS	WEIGHTED MATRIX SCORES							
		Plant	Sludge	Potable Supply	Power		UNIT		EVALUATORS		PLANNERS		COMM'L	
							H	RANK	H	RANK	H	RANK	H	RANK
1	I	64	agr	L.M.	no	1,6,11,17,22,24	0	19	0	22	0	21	0	19
2	II	33	agr	L.M.	no	2,7,12,18,22,24	-47.9	23	-26.5	23	-21.0	23	-49.6	23
3	II	33	agr	R.	no	2,7,12,18,23,24	-28.3	21	4.1	21	-3.9	22	-34.8	22
4	III	17	agr	L.M.	no	3,8,13,19,22,24	91.7	11	207.7	12	113.1	12	81.0	12
5	III	17	agr	R.	no	3,8,13,19,23,24	111.3	9	238.3	9	130.2	9	95.8	9
6	III	17	land	L.M.	no	3,8,16,19,22,24	182.5	4	347.2	4	201.1	4	140.8	4
7	III	17	land	R.	no	3,8,16,19,23,24	202.1	2	377.8	2	218.2	2	155.6	2
8	IV	DL	agr	L.M.	no	4,9,14,20,22,24	-29.5	22	34.6	20	12.4	20	-22.3	21
9	IV	DL	agr	R.	no	4,9,14,20,23,24	-9.9	20	65.2	19	29.5	19	-7.5	20
10	IV	DL	agr	L.M.	yes	4,9,14,20,22,25	24.1	18	98.6	18	52.6	18	31.3	18
11	IV	DL	agr	R.	yes	4,9,14,20,23,25	43.7	16	129.2	17	69.5	17	46.1	15
12	IV	DL	land	R.	no	4,9,16,20,23,24	85.1	13	221.1	11	124.0	11	56.9	13
13	IV	DL	land	L.M.	no	4,9,16,20,22,24	65.5	14	190.5	14	106.9	14	42.1	16
14	IV	DL	land	R.	yes	4,9,16,20,23,25	138.7	7	285.1	7	164.2	7	110.5	6
15	IV	DL	land	L.M.	yes	4,9,16,20,22,25	119.1	8	254.5	8	147.1	8	95.7	10
16	V	5+L	agr	L.M.	no	5,10,15,21,22,24	43.7	16	148.7	16	77.1	16	41.0	17
17	V	5+L	agr	R.	no	5,10,15,21,23,24	63.3	15	174.3	15	94.2	15	55.8	14
18	V	5+L	agr	L.M.	yes	5,10,15,21,22,26	89.6	12	201.7	13	112.1	13	87.4	11
19	V	5+L	agr	R.	yes	5,10,15,21,23,26	109.2	10	232.3	10	129.2	10	102.2	8
20	V	5+L	land	L.M.	no	5,10,16,21,22,24	141.7	6	305.3	6	173.4	6	106.7	7
21	V	5+L	land	R.	no	5,10,16,21,23,24	161.3	5	335.9	5	190.5	5	121.5	5
22	V	5+L	land	L.M.	yes	5,10,16,21,22,26	187.6	3	358.3	3	208.4	3	153.1	3
23	V	5+L	land	R.	yes	5,10,16,21,23,26	207.2	1	388.9	1	225.5	1	167.9	1

SYSTEM LIST -- NUMERICAL ORDER

* I refers to Conventional biological, II to physical-chemical, III to advanced biological, IV to distributed land, and V to plant and land.

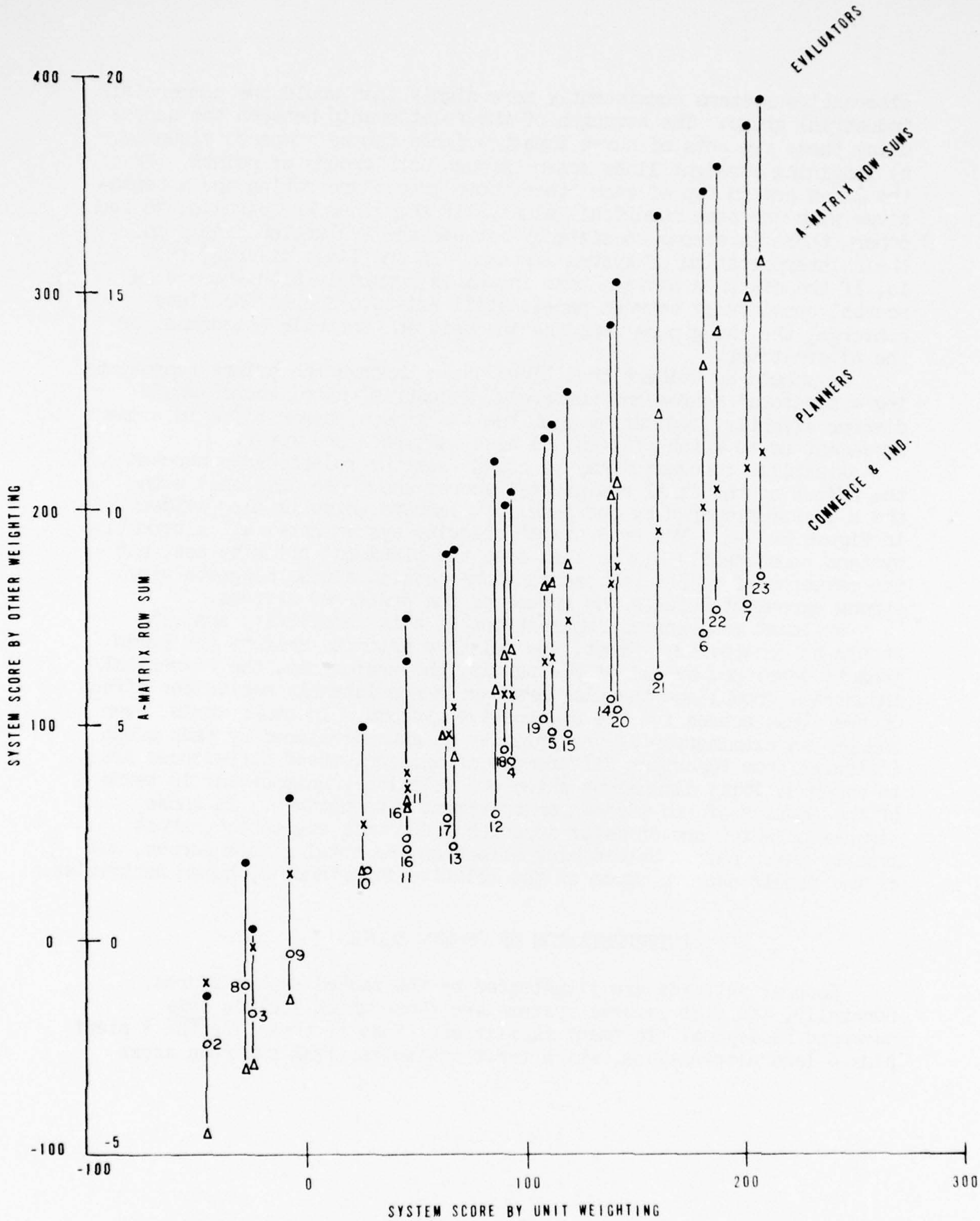

FIGURE E-IV-3
EFFECT OF WEIGHTING CRITERION ON SYSTEM SCORES

alternative systems consistently more highly than would the commercial/ industrial group. The strength of the relationship between the scores using these two sets of human impact weights can be compared visually by imagining straight lines drawn through both groups of points. If the lines are on top of each other, both groups are rating the alternatives with the same numerical values. If the lines are parallel to each other, there is strong consistency between the evaluation panels in their interpretation of system impacts. If the lines diverge, that is, if the distance between them increases regularly with increasing scores, consistency between panels still exists. Should the lines converge, the two groups would be inconsistent in their assessment of the alternatives.

It should be evident that lines drawn through the points representing evaluators' scores and commercial/industrial panel scores would diverge slightly, indicating that the two groups appear to be in close agreement as to which systems are best and which are worst.

A similar conclusion may be drawn from the relationship between the effect of the final evaluators' scores and those developed using the H vector prepared by the panel of planners which is also evident in Figure E-IV-3. The evaluators' priority system rates all alternative systems consistently higher than does the planners' priority set, but the patterns of points representing the sets of scores suggests very strong agreement between the groups on the preferred systems.

At least two general implications of this sensitivity analysis should be considered. First, the relative priority weights for human impacts developed by all of the panels, the evaluators, the commercial/ industrial group, and the planners have a consistently equivalent effect on the final scores for the alternative systems. In other words, even though an examination of the priority weights developed by each group indicates some important differences of opinion, these differences are in human activity dimensions which are relatively unimportant in terms of the impacts of the wastewater treatment alternatives. In those dimensions which are of major importance for this evaluation, those impacts which have a determining effect on the total system scores, all of the panels seem to agree on the relative importance of human activities.

INTERPRETATION OF SYSTEM SCORES

Several patterns are illustrated by the ranked system scores. Generally, the most favored systems are those which include some advanced biological treatment facilities. Some of these are the 5 plant plus 6 land alternatives, which treat wastewater from suburban areas

using land treatment. More specifically, the top six systems, in terms of ranks based on matrix scores, all include advanced biological plants; four of these six, including the most preferred system, are 5 plant plus 6 land alternatives. This suggests that the evaluators view both AB and land systems as relatively attractive alternatives. Probably because of the negative impacts associated with the taking of large tracts of land for the pure land alternatives, the distributed land plus plants concept is preferred.

Furthermore, it was suggested that the combination of AB plants and land treatment, with the latter serving the outlying areas around Chicago, seems particularly attractive from the perspectives of both the logical staging of construction and allowing feasibility testing of the land treatment concept on a large scale. For example, it would be possible to begin to expand and convert the five metropolitan CB plants, targeted to be used for the advanced biological concept, in the next few years. In the meantime, full scale tests of land treatment strategy could be carried out within the C-SELM area. If these tests served to prove the land concept, the 5 plant plus land scheme could be implemented. If not, it should then be possible to implement the 17 plant AB system, which would be built on the core of the 5 AB plants selected initially.

The rank order table also shows that the top ranking 8 alternatives all include land reclamation as the mechanism for sludge treatment. In fact, when all other elements of any two alternatives are the same, the evaluators indicate substantial preference for land reclamation over agricultural application for all types of systems except the physical-chemical and conventional biological alternatives. For those two concepts the land reclamation option was not considered.

Similarly, when all other elements of any two system alternatives are the same, the evaluators expressed an obvious preference for obtaining potable water through reuse of treated wastewater, as opposed to drawing additional water from Lake Michigan.

Finally, in the case of all alternatives containing land treatment facilities, those systems including the power synergism are always preferred to systems which are identical except for the absence of power.

TOTAL SYSTEM IMPACTS IN THE HUMAN ACTIVITY DIMENSION

The array of system element impacts presented in Table E-IV-1 can be further combined to reveal the impact of a complete system (an alternative with a particular selection of options) in each human activity dimension. This is accomplished by summing the impacts in each dimension indicated for that set of system elements comprising a single system. The results of such an analysis are displayed in Table E-IV-4.

The rows of Table E-IV-4 are organized in descending order according to wastewater management alternative (I to V) and within alternative by system number according to the type of sludge disposal and then according to potable water sypply. The dimensions of human activity are ordered so as to place those with the most positive impact on the left side of the table and those with the most negative impact on the right side.

Examination of the table reveals that all systems produce substantial positive impacts on aesthetics, ecosystem status and recreation. For

TABLE E-IV-4

TOTAL SYSTEM IMPACTS IN THE HUMAN ACTIVITY DIMENSIONS[1]

ALTERNATIVE	SYSTEM NUMBER	SLUDGE MANAGEMENT	POTABLE SUPPLY	POWER	AESTHETICS	ECOSYSTEM STATUS	RECREATION	HEALTH AND SAFETY	RESIDENTIAL ACTIVITY	FOOD PRODUCTION	IMMIGRATION	CULTURAL-EDUCATIONAL	POPULATION DENSITY	COMMUNITY SOCIAL STRUCTURE	COMMUNITY POLITICAL STRUCTURE	PUBLIC SERVICE	PUBLIC FINANCE	INCOME	PRIVATE SERVICE	EMPLOYMENT	CONSTRUCTION SERVICE	COMMERCIAL PRODUCTION	INDUSTRIAL PRODUCTION	SYSTEM SCORE (UNIT H VECTOR)
					16	17	15	10	7	3	8	13	9	19	18	5	14	12	6	11	4	1	2	
I-Ref	1	Ag	L.M.		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
II-PC	3	Ag	Reuse		7.5	9.7	8.8	-0.0	-1.8	-4.4	-1.1	-2.8	-3.0	-1.9	-2.1	-1.0	-2.7	-4.3	-2.1	-5.2	-7.2	-5.6	-8.2	-28.3
	2	Ag	L.M.		5.8	8.3	6.1	-1.3	-3.2	-4.8	-2.3	-4.2	-3.6	-2.3	-2.5	-2.1	-3.5	-5.2	-3.2	-6.2	-8.1	-6.6	-9.4	-47.9
III AB	7	Land	Reuse		34.3	30.2	31.6	16.7	18.8	8.2	12.7	9.7	6.7	5.0	5.5	6.4	5.5	5.4	5.0	4.0	0.6	1.3	-5.5	202.1
	6	Land	L.M.		32.6	28.8	29.3	16.3	17.4	7.8	11.5	8.3	6.1	4.6	5.1	5.3	4.7	4.5	3.9	3.0	-0.3	0.3	-6.7	182.5
	5	Ag	Reuse		23.8	23.3	21.8	10.2	9.3	8.8	5.4	3.5	1.8	1.6	1.9	2.6	2.0	1.7	1.3	0.2	-1.9	-1.1	-4.8	111.3
	4	Ag	L.M.		22.1	21.9	19.5	9.8	7.9	8.4	4.2	2.1	1.2	1.2	1.5	1.5	1.2	0.8	0.8	-0.8	-2.8	-2.1	-6.0	91.7
IV Land	14	Land	Reuse	Yes	30.4	28.5	27.1	13.9	11.6	5.8	8.3	4.6	4.7	2.5	2.6	2.5	2.9	2.0	0.6	0.7	-2.2	-2.6	-5.5	138.7
	15	Land	L.M.	Yes	28.7	27.1	24.8	13.5	10.2	5.4	7.1	3.2	4.1	2.1	2.2	1.4	2.1	1.1	-0.5	-0.3	-3.1	-3.6	-6.5	119.1
	12	Land	Reuse		30.2	29.1	25.7	12.0	7.5	2.7	5.0	3.1	2.2	2.1	1.3	-0.7	-0.2	-2.0	-2.8	-4.4	-6.5	-8.0	-11.1	85.1
	13	Land	L.M.		28.5	27.7	23.4	11.6	6.1	2.3	3.8	1.7	1.6	1.7	0.9	-1.8	-1.0	-2.9	-3.9	-5.4	-7.4	-9.0	-12.3	65.5
	11	Ag	Reuse	Yes	18.2	19.6	15.9	6.5	2.0	5.1	1.3	-2.1	0.1	-1.0	-1.1	-1.3	-0.3	-1.6	-3.0	-2.7	-4.2	-4.6	-3.2	43.7
	10	Ag	L.M.	Yes	16.5	18.2	13.6	6.1	0.6	4.7	0.1	-3.5	-0.5	-1.4	-1.5	-2.4	-1.1	-2.5	-4.1	-3.7	-5.1	-5.6	-4.4	24.1
	9	Ag	Reuse		18.0	20.2	14.5	4.6	-2.1	2.0	-2.0	-3.6	-2.4	-1.4	-2.4	-4.5	-3.4	-5.6	-6.4	-7.8	-8.5	-10.0	-9.0	-9.9
	8	Ag	L.M.		16.3	18.8	12.2	4.2	-3.5	1.6	-3.2	-5.0	-3.0	-1.8	-2.8	-5.6	-4.2	-6.5	-7.5	-8.8	-9.4	-11.0	-10.2	-29.5
V Land + AB	23	Land	Reuse	Yes	34.9	32.0	33.2	16.9	18.3	9.9	12.3	8.5	6.8	4.3	4.4	6.4	5.5	5.2	4.7	4.4	0.6	1.1	-2.6	207.2
	22	Land	L.M.	Yes	33.2	30.6	30.9	16.5	16.9	9.5	11.1	7.1	6.2	3.9	4.0	5.3	4.7	4.3	3.6	3.4	-0.3	0.1	-3.8	187.6
	21	Land	Reuse		35.0	32.6	32.0	15.3	14.6	6.9	9.4	7.5	4.5	3.9	3.4	3.6	2.8	1.9	1.8	0.1	-1.3	-3.3	-8.1	161.3
	20	Land	L.M.		33.3	31.2	29.7	14.9	13.2	6.5	8.2	6.1	3.9	3.5	3.0	2.5	2.0	1.0	0.7	-0.9	-4.0	-4.3	-9.3	141.7
	19	Ag	Reuse	Yes	22.8	23.8	21.8	9.6	8.5	9.9	4.9	1.8	1.8	0.7	0.7	2.3	2.1	1.3	0.7	0.6	-1.8	-1.4	-1.1	109.2
	18	Ag	L.M.	Yes	21.1	22.4	19.5	9.2	7.1	9.4	3.7	0.4	1.2	0.3	0.3	1.2	1.3	0.4	-0.4	-0.4	-2.7	-2.4	-2.3	89.6
	17	Ag	Reuse		22.9	24.4	20.6	8.0	4.8	6.0	2.0	0.8	-0.5	0.3	-0.3	-0.5	-0.6	-2.0	-2.2	-3.7	-5.5	-5.8	-6.6	63.3
	16	Ag	L.M.		21.2	23.0	18.3	7.6	3.4	6.4	0.8	0.6	-1.1	-0.1	-0.7	-1.6	-1.4	-2.9	-3.3	-4.7	-6.4	-6.8	-7.8	43.7

1 - The positive (+) or negative (-) numbers presented on this table do not connote beneficial or detrimental (i.e. good or bad). These figures present subjective assessment of the direction and magnitude of change, without deciding whether that change is given a value of good or bad.

Alternative II (the PC alternative) all other impacts are negative. Alternative III (17 plant AB), by contrast, produces strong to moderate positive impacts in all human activities except construction service and commercial and industrial production. Alternative V (5 AB plants + land) with land reclamation for sludge management is nearly identical in impact allocation to alternative III. Alternative V with agricultural utilization of sludge produces substantially more negative impacts in the areas relating to economic activity (right side of table). Alternative IV (land treatment) produces substantially more negative impacts than any other alternative except II, although the pattern is similar to alternative V.

SYSTEM IMPACTS IN THE THREE FUNDAMENTAL DIMENSIONS

The aggregate impacts of the 23 systems in each of the three fundamental dimensions (economic, human, food production) can be calculated by summing for each dimension, the impacts of the appropriate system elements comprising the systems. These aggregate impacts are displayed graphically in Figure E-IV-4. It is interesting to note that none of the systems produce positive impacts in the economic dimension (some are far more negative than others) and all produce positive impacts in the human-ecological dimension (again some are far more positive than others). The impact for food production is generally small for all systems, and negative only for the systems utilizing physical-chemical treatment (systems 2 and 3). The small impact on food production was expected since the implicitly weighted system element scores were used rather than the unit-weighted ones in calculating the system scores. As was indicated earlier, an equal weighting of each of the three dimensions would change the graphs only to the extent that the food production score would be magnified several-fold.

The fact that food production impact scores are small suggested that a look at the impacts resulting from the two principal dimensions (economic and human) alone might be revealing. Recall that these two dimensions contribute about equally to the average system scores and that the two together account for about 93% of the variation in system scores.

First to be examined are the system element scores. Figure E-IV-5 is a graphical display of the 26 system elements plotted according to their scores in each of the two fundamental dimensions: economic (vertical axis) and human (horizontal axis). Thus element 16 is the highest scoring element in the human dimension while element 25 is the highest scoring element in the economic dimension. The diagonal lines represent combined impact scores if the two dimensions are weighted equally. Higher (more positive) combined impacts correspond to diagonals near the upper-right corner of the graph while low (more negative) combined impact scores correspond to the diagonals at the lower left corner of the graph.

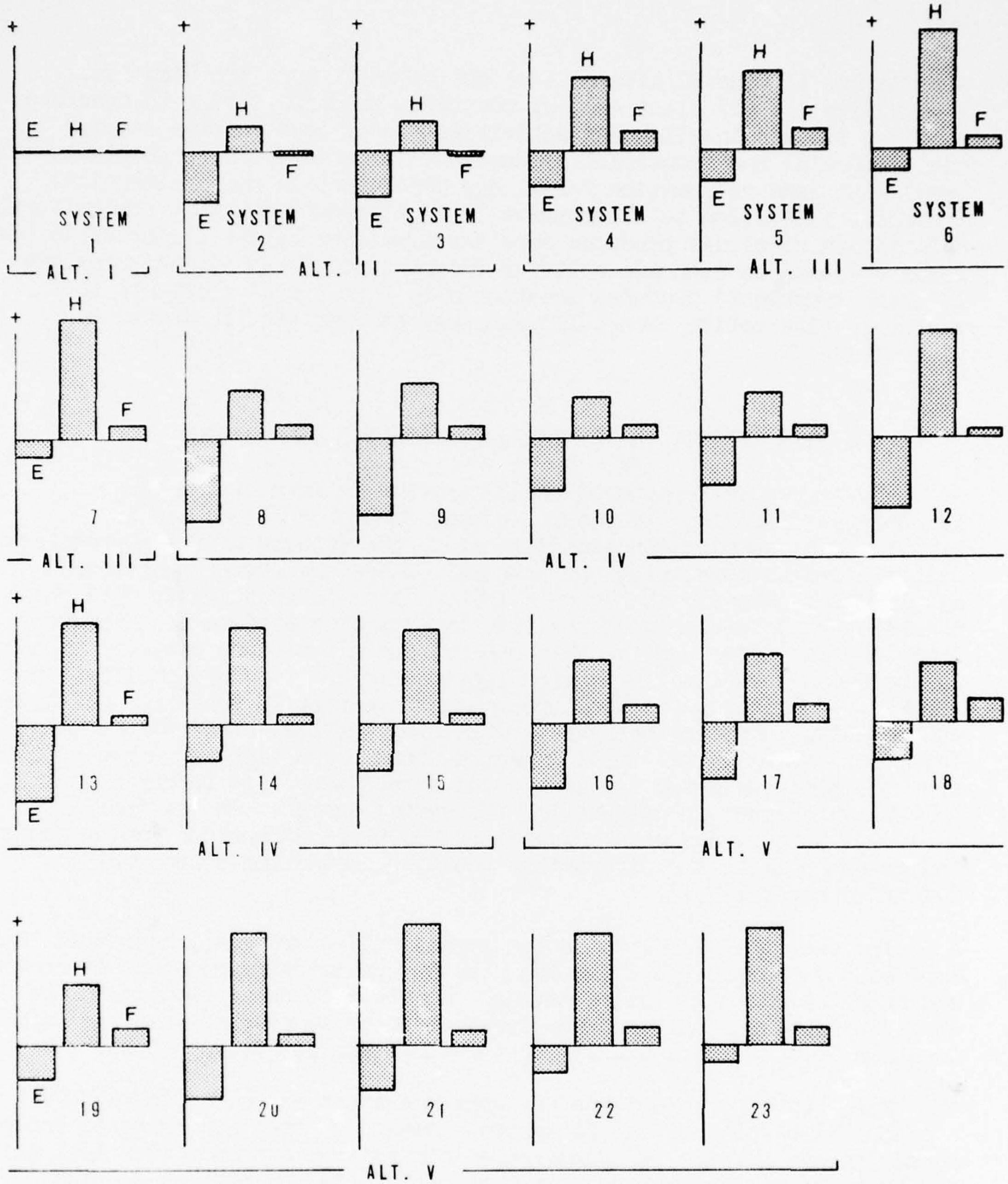

FIGURE E-IV-4

SYSTEM SCORES IN THREE FUNDAMENTAL DIMENSIONS
(IMPLICIT WEIGHTINGS)

E = ECONOMIC H = HUMAN F = FOOD PRODUCTION

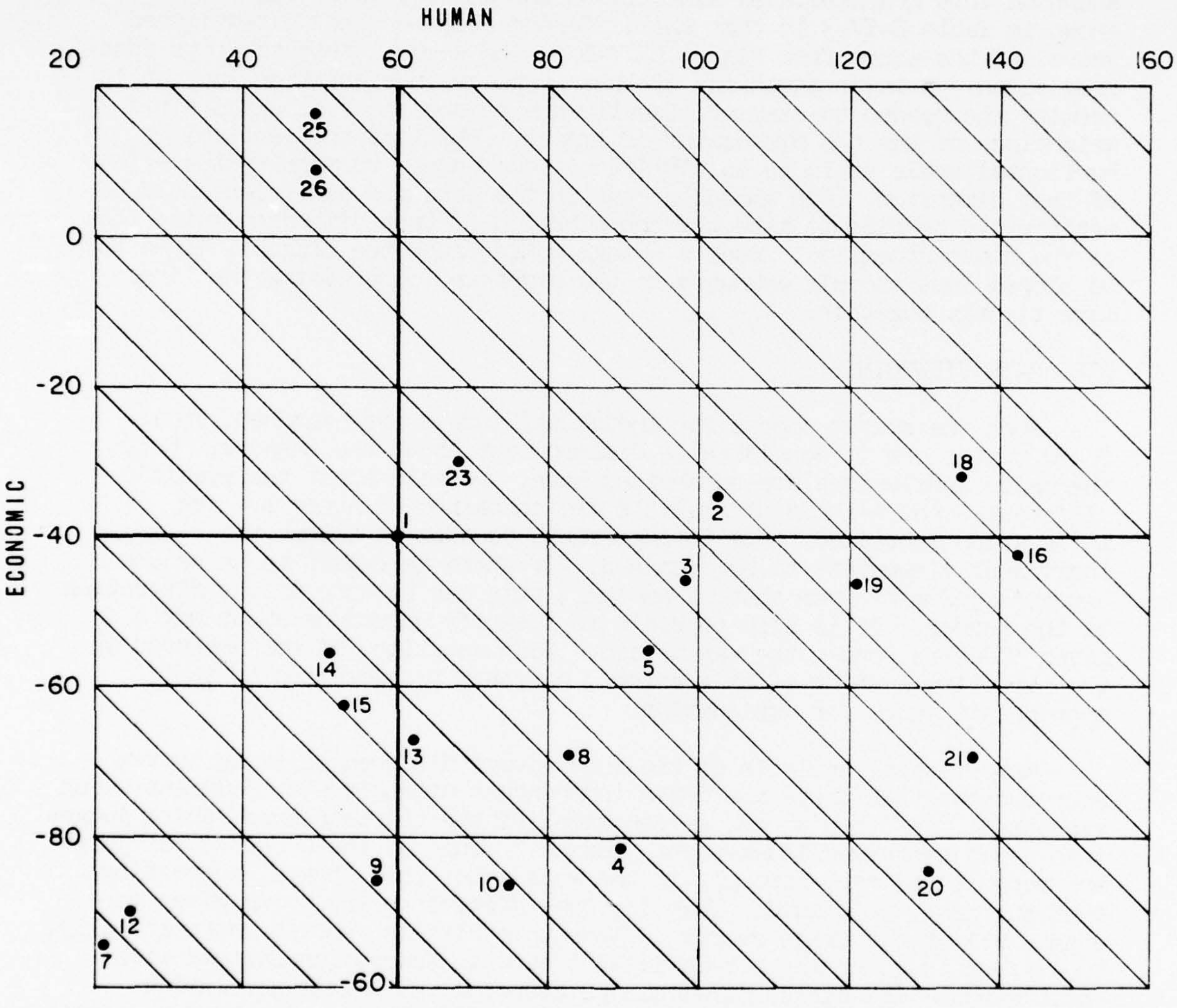

FIGURE E-IV-5

SYSTEM ELEMENT SCORES IN THE ECONOMIC AND HUMAN DIMENSIONS

These system element impact scores can also be utilized to calculate total system scores in these two dimensions. Figure E-IV-6 provides a graphical display of these system scores in the economic (vertical) and human (horizontal) dimensions. Again the diagonal lines represent the combined impact scores for the two dimensions according to their implicit (unequal) weightings. The numerical score for a system as shown on this graph relates directly to the unit-weighted system score shown in Table E-IV-3 in that the difference between the unit-weighted score and the score from Figure E-IV-6 is the score attributable to food production. A major advantage of this graphical presentation is that it permits the reader to examine visually the consequences of any desired weightings of the two dimensions of impact. That is, the vertical or horizontal scale could be multiplied by some number to magnify the effect of that dimension. The impact scores in the economic dimension could be arbitrarily doubled to make the contribution of that dimension twice that of the human dimension. Such a change would cause the diagonal lines to be sloped less steeply downward to the right and compressing the lines more tightly together.

DISPARATE VIEWPOINTS:

When the system scores for individual judges are examined, it is found that there is considerable disagreement about the impacts. Only the major conclusions are summarized here. Details about the specific differences and methods of analysis are contained in Annex B. The information contained there is important, because it allows the individual viewpoints to be examined. If there is reason to value one expert's judgment over that of another, this can be done at the discretion of the reader. It is also possible to identify questions about why a given judge responded the way he did. Such question, if not answered in the narrative section of this report, can then be addressed to the appropriate judge for explanation.

Mathematical analysis of the inter-judge differences among system scores shows that there are seven independent dimensions of judgment being expressed. In other words, we can simplify the thirteen overlapping judges into seven contrived independent "judges." Some of these contrived "judges" are represented more strongly in the real panel than others, suggesting that our panel is biased. That is, some viewpoints are being given more emphasis in the average results. When this bias is removed mathematically, the effect is generally a relative increase in scores for systems with potable reuse and agricultural sludge disposal. There is a relative lowering of the type V system scores. The land systems with land reclamation tend to fall slightly while land systems with agricultural sludge disposal tend to rise slightly. The system with the best "unbiased" average score is number 7 (17 plant AB with land reclamation and potable reuse), followed by 14 (land treatment), 23 (AB plus land), 4 (17 plant AB), and 15 (land treatment). The best three all include land reclamation and potable reuse.

If it is believed that the judges are all equally credible and that disagreements arise because each is considering an incomplete and somewhat different part of the whole, then the unbiased average is the most meaningful composite score. However, if some judges are more correct than others, the biased view is best, because it tends to be influenced by consensus, i.e., overly represented points of view.

In general there is disagreement about all systems, except the reference system, which is zero in all viewpoints by definition. For the other systems, there is about twice as much disagreement on #3 (PC) where the least consensus occurs, as on #7 (17 plant AB) where consensus is best. System #7 is also the most desirable with regard to the unbiased average score. Systems 2 and 3 (both PC), which are among the least desirable, are also among those for which disagreement is greatest. The only other obvious regularity is that the systems including the power option are all in the middle range of disagreement at about the same level.

When the thirteen judges are simplified mathematically into the seven independent dimensions of judgment, and when these seven dimensions are weighted equally to remove bias, it is possible to examine multivariate differences among systems. That is, it is possible to compare systems in terms of all the points of view, including all disagreements. When comparisons are made in terms of average scores, much of the individual viewpoint is lost. If it is assumed that each judge has expressed an important and valid part of the impact, the multivariate comparison among systems is more meaningful than the average. Analysis shows that the potable needs option has relatively little effect on impact and is the least important system variable. If this option is removed, we can reduce the set of systems from 23 to 12 with a loss of only about 15% of all inter-system differences.

With regard to system types IV and V, the sludge disposal option creates greater differences in impact than the treatment process when power is not present. However, when power is present, differences in treatment processes are more important than sludge disposal. In fact, type IV with power resembles type III in total impact more than it resembles any other system category, including type IV without power. Type V and type IV without power tend to resemble the reference system more than they resemble type III or type IV with power. Types I, III, IV and V are more similar to each other than to system type II (the physical-chemical treatment). This treatment process is in a category by itself, producing a very different spectrum of impacts.

Description and explanation of the specific ways the judges disagree with each other is too complex a task to include in this summary. The information in Annex B shows that the disagreement is extensive with respect to treatment process, sludge disposal, power, and potable reuse. These disagreements are described in the Annex, and a simplified version of the individual A-matrix allows the reader to reconstruct the specific impacts that have been judged to occur. For explanation of these impacts, the narrative comments in Section V and/or the judge himself must be consulted.

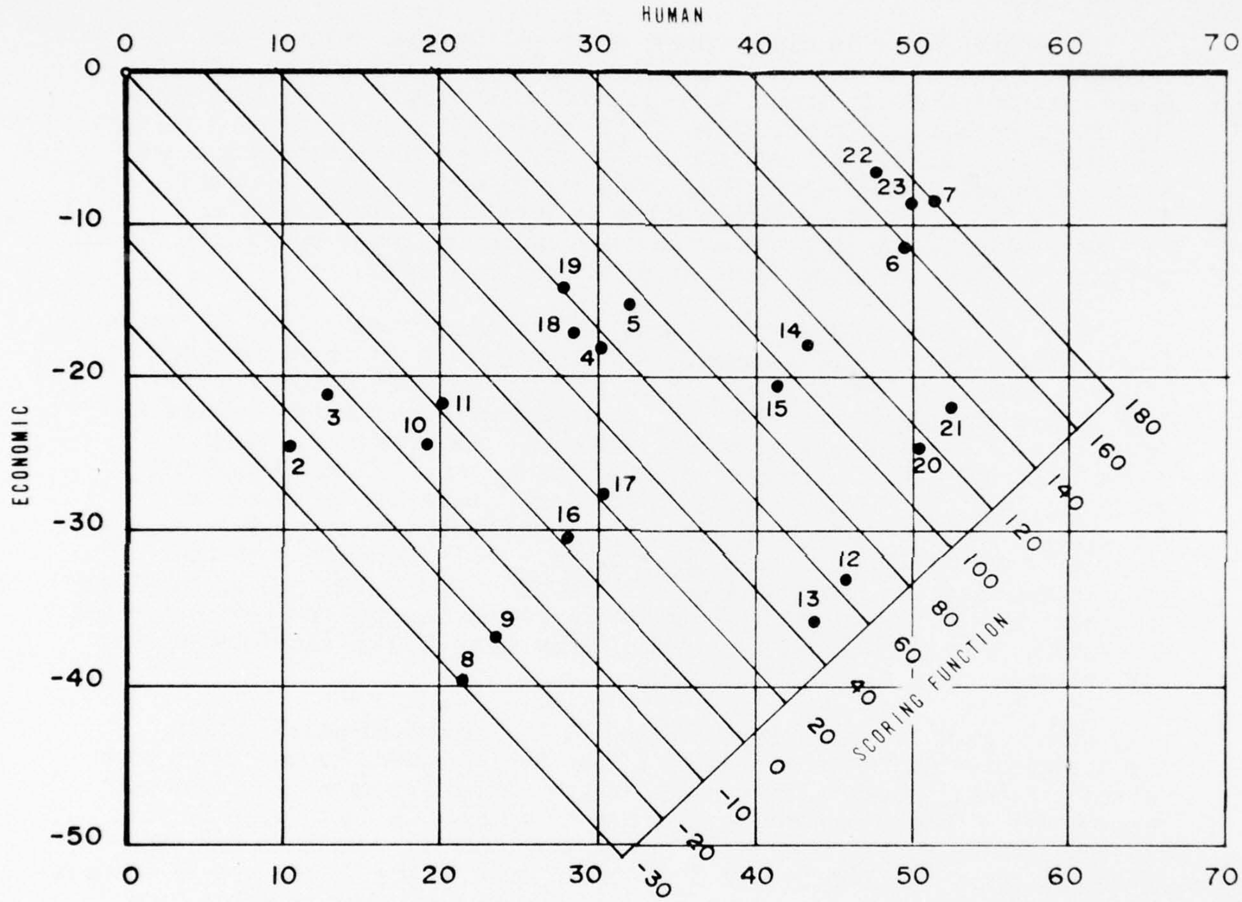

FIGURE E-IV-6

SYSTEM SCORES IN THE ECONOMIC AND HUMAN DIMENSIONS

SECTION V: THE IMPACTS AS EXPLAINED BY THE EVALUATION TEAM

INTRODUCTION

The preceding sections describe the results of the numerical estimates of system impacts. This section identifies the implications envisioned by individual members of the evaluation team, while rating the numerical "A" matrix (social-environmental) impacts. The stimulation of such comments was one of the primary purposes of the numerical procedure.

We recognized from the start that technological impact is a complex multi-disciplinary phenomenon that cannot be treated adequately by any one person or discipline. Therefore, a panel of varied specialists was selected, and a strategy developed that could extract their wisdom. The strategy is multi-faceted, focusing on several objectives.

1. Educating the panel members about the alternative systems and their impact processes;

2. Catalyzing communication and interaction among the various academic disciplines;

3. Forcing numerical judgements on specific aspects of impact as defined in the matrix structure, and

4. Stimulating the panelists to examine the system impacts microscopically and systematically and to record their comments on and explanations of specific impacts.

In a sense, the numerical procedure might be regarded as an educational game, with verbalized comments and explanations from individual panelists being the ultimate product. When viewed in this way, the numbers are a means to an end rather than an end in themselves. Nevertheless we believe we have shown that numerical analyses contain much useful descriptive information. Likewise we believe that the following narrative contains useful explanations.

Where consensus occurs, it is clearly indicated. However, in several instances different points of view were expressed concerning the impacts of particular system elements. (See Annex B for a technical analysis of the different view points) Where differences of opinion exist the several opinions are each expressed. The comments are discussed in terms of the five module categories encompassing the systems and, additionally, includes a discussion of the various management proposals for all excavated materials.

METHOD USED TO CATEGORIZE IMPACT ANALYSES

In accordance with the wishes of the Chicago District, U.S. Army Corps of Engineers, the environmental and human impact parameters identified in our Evaluation Methodology will be discussed in the context of the following categories: Ecological, Social, Aesthetic, Hygienic, and Economic. The design components of the wastewater management systems will again serve as major discussion categories following the format already established in previous sections of the report. The five subcategories, as underlined above, will include the following parameters:

Ecological

Surface Water Quality
Surface Water Quantity
Subsurface Water Quality
Subsurface Water Quantity
Air Quality
Soil Quality
Rare and Endangered Species
Terrestrial Biotic Communities
Aquatic Biotic Communities
Mineral Resources

Social

Public Service
Private Service
Immigration
Population Density
Employment
Access to Cultural/Educational Activities
Recreation Opportunities
Community Political Structure
Community Sociological Structure
Cultural/Scientific Sites
Present and Potential Land Use

Aesthetic

Residential Area Quality
Park/Greenbelt/Open Space Quality
Commerce Area Quality
Odor
Noise
Agriculture Area Quality

Hygienic

Health
Safety

Economic

Commercial Production
Industrial Production
Agricultural Production
Industrial Production
Construction Services
Employment
Income
Consumption of Goods and Services
Public Finance

COLLECTION, TRANSPORTATION AND STORAGE OF INPUT WATER

Comments in this category are related to 1) impacts arising from the collection and storage of stormwater; and 2) impacts attributable to the differences in collection, transportation, and storage required by differing numbers and locations of treatment facilities.

MANAGEMENT OF STORMWATER

The reference system (I) provides for management of some urban and suburban stormwater. Common to all the NDCP alternatives (systems II, III, IV and V) however, is the management of nearly all of the stormwater in rural, suburban and urban areas.

Some of the most positive impacts ascribed to the various wastewater management components in our evaluation show up in surface water quantity and quality as affected by the collection, transportation and storage component. The evaluators very clearly attribute this to the stormwater management provisions of the Alternatives II through V and this is reflected in the essentially equivalent positive scores for all these systems. Since in this category we are dealing with collection and storage (treatment is considered in a latter section), surface water quantity is judged to be somewhat more positively affected than quality when Alternatives II through V are compared to Alternative I. The reasons for this become clearer in the following discussion.

Ecological

a. Surface Water Quality Surface water quality is improved by prevention of sudden influxes of large quantities of pollutants contained in overload flows that occur during storms. "First flush" stormwater and agricultural runoff contain a high level of BOD and suspended solids, as shown on Table E-V-1.

TABLE E-V-1

STORM RUNOFF QUALITY PARAMETERS

Nature of Area	Soluble Phosphorus Mg/1	BOD Mg/1	Suspended Solids Mg/1
Urban-Served by Combined Sewers	1.0	10	130
Suburban-Served by Separate Sewers	0.25	20	500
Rural-Served by (Partially) Storm Sewers	1.0	10	550

* Reference Appendix A

Most of the storm runoff, including agricultural runoff, eventually finds its way to C-SELM streams rather than Lake Michigan. Therefore, except for a few urban areas like Gary, Hammond, Whiting and East Chicago in Indiana and Lake County in Illinois, where other stormwater management techniques are necessary, the major improvement in water quality from stormwater collection will occur in the streams, not Lake Michigan.

b. Surface Water Quantity Surface water quantity is effectively regulated through the collection and storage of substantially all runoff in the C-SELM area. Temporal and spatial availability of surface water is thus controlled. Flood plain relief achieved thereby in the C-SELM area is calculated to be 59,900 acres.

c. Subsurface Water Quality and Quantity Subsurface water quality and quantity is not expected to be affected since the storage impoundments are to be sealed. On the other hand, these impoundments could be located and designed so as to enhance groundwater recharge, particularly in suburban "need centers". In such suburban "need centers" the quantity of groundwater would be increased and the evaluators viewed this favorably (positively). The groundwater quality may be somewhat unfavorably (negatively) affected, particularly in terms of TDS (Total Dissolved Solids) but the final use of the water should not be impaired. Overall, the evaluation team rated this positively and recommends further investigation of this possibility.

d. Energy Resources One negative impact of the stormwater management aspect of the NDCP Alternatives is on energy resources. This is negative only in the context of consumption of energy. Considerable energy (calculated at 1240 megawatt hours/day in 1990) is required to pump stormwater which has been collected around the C-SELM area for storage and treatment. As the above figure indicates, however, there is no discrimination among the several NDCP alternatives in this respect.

e. Biotic Communities Construction of rural stormwater management systems results in an increase of standing water biotic communities (ponds) and a reduction in flowing water (streams) and terrestrial communities (land areas). This trade-off is not viewed as having a negative effect on the distribution or diversity of biotic communities in areas already highly modified by man. In undisturbed areas, however, such management is potentially destructive of certain types of biotic communities (e.g., prairie patches, marshes, forest stands) and unique or rare species (e.g., Prairie Chicken). The specific site characteristics of all such areas must therefore be studied; some areas may be used if extreme care is taken, while others may have to be completely avoided. The nature of the C-SELM study did not enable detailed design locations nor impact analysis of specific locations. Stormwater storage lagoons should not create any mosguito problems, due to fluctuating water levels and the presence of viable fish populations.

Social

a. Public and Private Service There will be some degree of disruption in terms of public and private access to transportation and communication services at the time of construction of the collection and storage systems (pipelines and impoundments) which results in a temporary negative impact. Over time, however, this should prove minimal.

b. Recreation Opportunities There will definitely be an increase in recreational and open space because of the stormwater management characteristics of Alternatives II - V. Some part of this could be potentially provided by the streams and the adjoining flood plain. Another part will be provided by the rural and suburban stormwater impoundments if properly designed and made accessible to the public. Furthermore, these facilities should be designed as a recreational resource; they should, if at all possible, be accessible to the public for boating, fishing and picnicing.

c. Present and Potential Land Use An equal amount of land is required by Alternatives II-V for rural and suburban storage to effect the regulation of stormwater, viz. 20,300 acres of suburban land purchased for 1990, 17,548 acres of rural land purchased and 104,148 acres utilized in 1990. Offsetting these losses is the 59,900 acre gain from floodplain relief noted above. Some negative impact on agricultural land use is suggested by the evaluators for those areas where land is taken out of production for stormwater storage. With careful siting,

this impact should be minimal. The rural and suburban impoundments must be sited so as to not seriously interfere with present residential land use or in areas which have high potential for such use. For example, the Porter County, Indiana site, used for illustrative purposes by the C-SELM design engineer has a pond scheduled for an area on which there are presently a great many modern residences. We realize, of course, that this sort of problem will be obviated as final locations of all system components would be carried out only after full field investigation. But the incident focuses attention on the fact that there are certain areas--such as this morainal area in Porter County--which by virtue of their soils and location near population growth centers are eminently suitable for residential purposes. It would be wise to recognize this in locating the management systems so as to avoid considerable phasing out of the ponds from their primary stormwater collection use when an area changes its land-use designation. On the other hand, the ponds can be phased quite well into the urban environment.

The use of flood plain lands made available by flow control must be carefully regulated. Such lands should be reserved only for agriculture, recreation, and other open space uses for only these types of activities can sustain flooding over time.

Aesthetic

a. Residential/Open Space Quality The stormwater storage ponds should be landscaped so as to complement residential and open space land use; irregular shoreline and aesthetically pleasing relief would be desirable. According to the information received from the engineering consultant, these design criteria would be incorporated.

The above improvements in surface water quantity and quality may be accompanied by some enhancement of sensory quality, for example clearer water in C-SELM streams (not choked with algae and debris) and relief from flooding unsightliness.

Hygienic

a. Health The evaluation team has expressed some concern relative to the use of stormwater impoundments for body contact recreation. Effective monitoring is suggested prior to and during the use of these impoundments for swimming. The use of impoundments for these purposes, if desired by rural communities, would require appropriate chlorination to meet all health standards set for Indiana and Illinois.

b. Safety The reduction in flooding potential for C-SELM streams (59,000 acres) has a significant positive impact on the safety of people and development now located in or near flood plains.

Adequate management and supervision are required in order to control and assure safe use of the stormwater management ponds.

Economic

a. Income. Ways should be found to minimize the impact of stormwater management impoundments on the land-use, particularly in the rural areas. Perhaps a lease arrangement similar to that proposed for the land treatment areas outside the C-SELM Region could be arranged which would allow the farmer to continue to farm the land utilized for rural storm water treatment. Also in some situations, access to the water impoundments may be provided for stock watering.

NUMBER AND LOCATION OF TREATMENT PLANTS AND LAND SITES--EFFECT ON COLLECTION AND STORAGE

As the number of treatment plants decreases, an increase is expected in the number and length of pipelines and tunnels for wastewater conveyance, though the specific location of the plants also is a factor. The graphics provided by the design consultant appear to confirm this expectation.

Ecological

a. Terrestrial Biotic Communities Most of the impacts associated with the construction of the conveyance system (pipelines) would cause only temporary and localized environmental disruptions. Comments are directed at the disturbance of biotic communities and unique or rare things which would be irreparably altered and which are likely to accompany pipeline construction. The more extensive these pipelines the more negative this impact is judged to be. For example, pipelines that impact on the Indiana Dunes National Lakeshore, an area encompassing several unique and particularly fragile biotic communities, and other similar natural areas, are considered to be especially deleterious.

Tunnel construction will not, necessarily, involve surface disruption. In fact, the removed tunnel spoil materials can be put to good use, as discussed later.

b. Mineral Resources The extensiveness of the conveyance system is not judged as having a negative impact on mineral resources. This is probably because the evaluators felt that the resources consumed in pipeline construction were relatively abundant and because the tunneling will produce considerable quantities of aggregate materials.

Social

a. Access Various disruptions to access (communication facilities, transportation, etc.) will occur when the pipeline conveyance aspects of the wastewater management systems are constructed. These disruptions will primarily be temporary inconveniences characteristic of construction such as traffic rerouting, etc.

b. Potential Land Use The location of sewage conveyance pipelines will influence residential developments, in particular. Growth will follow conveyance lines, if free access is provided.

Aesthetic

The aesthetic impacts expected when implementing the pipeline conveyance system include noise, dust and visual contrasts with normal conditions. Obviously, the more pipeline conveyance involved, the greater the significance of the impact.

Hygienic

Pipeline construction guidelines dictate safety requirements. The evaluators have accepted these guidelines as acceptable assurance of adequate safety measures.

Economic

a. Energy Resources Though the several systems differ very little in their overall energy requirements for stormwater management, they do differ in their energy requirements for wastewater conveyance as a result of the differing numbers and locations of the treatment facilities. It is calculated that 548 megawatt hours/day will be required for Alternative I in 1990, 592 for II, 567 for III, 801 for IV and 714 for V. The total energy requirements for these combined functions is considered sufficiently large to judge all NDCP Alternatives as having a negative impact with respect to this parameter. Differences between the NDCP sytems are considered large enough to judge Alternative IV as having a much greater negative impact in terms of electrical consumption than Alternative II and III, with system V having an intermediate negative impact when compared to Alternatives II, III and IV.

TREATMENT FACILITIES AND PROCESSES

In assessing the impacts resulting from the treatment facilities and processes, the evaluators viewed these as "factories" (structures and/or areas within which the wastewater treatment processes takes place) without regard to the final product. Since the improvement in water quality is evaluated in a different category and is considered later in this section, it would then be understandable that the impacts of treatment facilities and processes are mostly negative, reflecting the consumption of land, energy and mineral resources in the construction and operation of "factories". Moreover, these "factories" affect sensory and aesthetic qualities in their vicinity, produce air pollutants and influence access in terms of transportation, communication and service.

In this category of system elements, several themes of comments emerge: a) advanced biological treatment versus physical-chemical treatment, b) land treatment versus advanced biological treatment; and c) the effect of number of plants, number of land sites, or mix configuration on various impacts. Each theme is discussed below.

ADVANCED BIOLOGICAL TREATMENT VS. PHYSICAL-CHEMICAL TREATMENT

Ecological

a. Air Quality Because of the incineration processes associated with PC plants, the impact on air pollution and sensory quality in urban areas is expected to be significantly more negative than corresponding impacts from AB plants as shown in Table E-V-2.

TABLE E-V-2

AIR POLLUTANT EMISSIONS C-SELM ALTERNATIVES

	Alt. 1		Alt. 2		Alt. 3		Alt. 4		Alt. 5	
	1990	2020	1990	2020	1990	2020	1990	2020	1990	2020
Sulfur Dioxide Tons/Day	None		1.3	1.6	0.1-1.0	0.1-1.0	None		0.1-1.0	0.1-1.0
Particulates Tons/Day	None		10.3	12.2	6.7	8.2	None		4.1	5.3
Nitrogen Oxides Tons/Day	None		540	635	1.9	2.3	None		14	15
Aerosols	Present		None		Present		Present But Screened		Present But Screened	

Obtained from engineering specifications provided to Evaluation Team by BEI.

b. Biotic Communities Although the cause and effect relationship of air pollutant emission on biota are not well documented in the literature especially at the levels indicated above, the evaluators felt that the PC process relative to the AB and land processes produces emissions that may have a long term negative effect on biotic communities when added to those emissions already present in urbanized areas.

c. Mineral Resources The PC process does not foster a wise use of resources. It takes potentially useful and recyclable material resources and significant energy resources and converts them into noxious air pollutants as well as less useable sludge. The comparative resource requirements are identified in Table E-V-3.

Clearly, among the alternatives, the PC process is the most consumptive of natural resources. Particular concern was expressed over availability of natural gas supplies. Table E-V-4 indicates resource depletion estimates under various conditions. If the low estimate of ultimately recoverable resources is correct, the outlook for domestic gas is grim despite massive imports (60 percent of domestic supply) and an accelerated development of synfuel production facilities.

Social

a. Immigration As indicated in Table E-V-5, the PC plants require significantly fewer relocations than AB plants which might counterbalance the negative impacts (air and sensory quality) in the short run. In the long run, (50 year system life) however, relocation impacts would not have a significant negative impact. It is suggested that more detailed site design at a future date may reduce the impact of relocation by including appropriate relocation considerations as a specific design factor.

b. Present and Potential Land Use Air pollution from PC plants will have a significant negative impact on residential land use for some distance around the plant (e.g., the former incineration facilities at the Stickney plant). If, however the PC plant is located in an area already highly industrialized, the effect on residential land use would lose significance.

Aesthetic

The air pollutants generated from PC plants will impact on people via visual and odor parameters. PC plants are therefore considered negative relative to the other technologies evaluated.

Hygienic

No correlation has been established between the expected pollutant emission concentrations from the PC or AB plants and incidence of disease. However, introducing additional air pollutants into an area

TABLE E - V - 3

RESOURCE IMPACT

	Alternative I		Alternative II		Alternative III		Alternative IV		Alternative V	
	1990	2020	1990	2020	1990	2020	1990	2020	1990	2020
Natural or Synthetic Gas, Billion Btu/Day	- 11.2* 13.3**	- 13.6* 16.1**	160	190	87 11.2* 13.3**	100 13.6* 16.1**	-	-	63 8.2* 9.7**	68 9.9* 11.7**
Chlorine Tons/Day	45	53	51	62	51	62	51	62	51	62
Clinoptilolite, Tons/Day	-	-	240	290	-	-	-	-	-	-
Lime, Tons/Day	-	-	2700	3200	1900	2300	-	-	1400	1500
Sodium Chloride, Tons/Day	-	-	480	560	-	-	-	-	-	-
Aluminum Sulfate, Tons/Day	160	210	250	300	250	300	-	-	180	200
Polymer, Tons/Day	-	-	1.3	1.5	1.3	1.5	-	-	0.91	0.98
Activated Carbon, Tons/Day	-	-	100	120	50	60	-	-	37	40
Methanol, Tons/Day	-	-	-	-	500	600	-	-	360	390

* Natural Gas produced and consumed by heated anaerobic digestors.
** Excess Natural Gas produced by heated anaerobic digestors.

TABLE E-V-4 *

RESOURCE DEPLETION ESTIMATES FOR VARIOUS SCENARIOS

Fuel and case description	Year in which all ultimately recoverable resources are depleted: Low estimate EGM**	Low estimate RGM***	High estimate EGM	High estimate RGM
Natural gas:				
No imports, no synfuel	1989	1991	2000	2007
No imports, synfuel	1990	1992	2008	2016
Imports, no synfuel	1993	1997	2010	2025
Imports, synfuel	1996	2000	2037	(****)
Petroleum:				
No imports, no synfuel	1988	1988	2011	2014
No imports, synfuel	1989	1989	2027	2030
Imports, no synfuel	2001	2003	2031	2038
Imports, synfuel	2006	2008	(****)	(****)
Coal:				
No synfuel	(****)	(****)	(****)	(****)
Synfuel	2032	(****)	2044	(****)

* The Table above was taken from a report of a "Cornell Workshop on Energy and the Environment" sponsored by the NSF RANN Program, and issued by the Senate Committee on Interior and Insular Affairs.

** EGM - an extrapolated growth model which assumes past exponential growth in demand for gas, petroleum and electricity at 6.2 percent, 3.9 percent and 6.1 percent per year, respectively.

*** RGM - a reduced growth model which assumes that growth in total demand for gas, petroleum, and electricity drop to 3 percent, 3 percent and 4 percent per year, respectively.

**** Beyond 2050

TABLE E-V-5

PEOPLE IMPACT - NUMBER OF PEOPLE DISPLACED

Alternatives	I			II			III			IV			V		
	R	S	U	R	S	U	R	S	U	R	S	U	R	S	U
Wastewater Treatment Facilities	200	800	6,300	75	725	1,625	-	2,120	24,600	2,750			920		23,600
Rural Stormwater Impoundments				13,000			13,000			13,000			13,000		
Totals	200	800	6,300	13,075	725	1,625	13,000	2,120	24,600	15,750			13,920		23,600
Total By Alternative		7,300			15,425			39,720			15,750			37,520	

R - Rural
S - Suburban
U - Urban

already containing significant amounts of industrial stack emissions may have significance in the long run. Although the effects of chronic but low levels of exposure to air pollutants are not very certain, evidence is slowly accumulating that suggest an association between such levels of pollution in urban communities and mortality and morbidity rates due to lung and bronchial cancer, chronic bronchitis, emphysema, asthma and pneumonia. Most experts seem to agree that respiratory disease rates are higher for persons whose occupation, place of residence or level of activity brings them into more than average contact with pollutants normally found in urban areas. (1,2) In addition to such serious diseases, problems such as eye irritation, throat irritation and colds also have been mentioned as being associated with increased levels of air pollution. (3)

Economic

a. Public Finance It is important to note that the increased land requirements for AB over PC occurs in urban areas at relatively high incremental land costs.

LAND TREATMENT VERSUS TREATMENT PLANTS

For the purposes of this assessment, the treatment effectiveness of the land treatment process was assumed equivalent to that achieved by the other "plant" technologies. Thus as with the other treatment processes the social environmental assessment was predicated on the design and performance data furnished by the Chicago District and its technical consultants.

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(1) John R. Goldsmith, "Effects of Air Pollution on Humans," Vol. I, Chap. 10, of Arthur C. Stern (Ed), Air Pollution (New York: Academic Press, 1962), pp 335-83.

(2) Also see Louis D. Zudberg, Robert J.M. Horton and Emanuel Landau, "The Nashville Air Pollution Study: V. Mortality from Diseases of the Respiratory System in Relation to Air Pollution," (mimeo, presented before the Epidemiology Section of the American Public Health Association, Kansas City, Missouri, November 12, 1963) and references cited there.

(3) Goldsmith op cit., p 368

Ecological

a. Subsurface Water Quality Incorporation of the land treatment system will involve the intermingling of treated wastewaters with existing groundwater in the land treatment area. In fact, over a period of time (as yet not clearly defined) wells for potable supply used by persons living within land treatment areas will have the same constitutent levels including the TDS (total dissolved solids) concentrations expected in the treated wastewater. As in the stormwater impoundment section, the evaluators recognize that the subsurface water quality will be negatively affected over time. However, the significance of this is not judged to substantially impair the ultimate use of this water for domestic needs.

The aeration-digestion and storage lagoons are not expected to affect groundwater quality, since adequate sealing and/or underdrainage are to be provided.

b. Air Quality If the design of irrigation equipment will maximize droplet size, and therefore minimize aerosol transport, there should not be any air quality problem in adjoining areas.

Adequate buffer vegetative zones around aeration-digestion lagoons should assure minimal transport of aerosols. These lagoons should be located inside an irrigated land perimeter to add an extra safety factor.

c. Soil Quality If the land systems perform as reported, soil conditions are likely to improve in that the organic content and nutrient values would be increased. This improvement, however, should be evaluated in reference to time and as included in design, an effective monitoring program maintained. It is very difficult to predict the effect of continuous land treatment on the mechanical properties of the soil. The land system does conserve nutrient resources through the recycling of wastewater nutrients. On the other hand, when the effluent of the land treatment systems (Fig. 4, "The Use of Land as a Method of Treating Wastewater - Its Meaning to the Agricultural Community", Dec., 1972) is compared to the water applied (Fig. 2, ibid.) it is seen that there is considerable reduction in Cu, Zn, Fe, Mn, Bo, oils, grease, phenols, trace metals, arsenic and cyanide. Moreover, regular application of pesticides and herbicides is called for. Some of the organic substances are biodegradable, and hopefully, all the pesticides and herbicides will be, but essentially all the other materials accumulate, and this can be judged as nothing other than a negative effect on soil quality. There is a question, however, as to how negative this effect is vis a vis dumping these pollutants into natural bodies of water. The research program currently being conducted by the University of Illinois indicates both the feasibility and effectiveness of maintaining soil quality through sludge application.

d. Terrestrial Biotic Communities Intrusion of a spray irrigation system onto agricultural land is not necessarily considered detrimental to existing biotic communities. However, the underdrainage system will cause a ground water drawdown within and immediately adjacent to land treatment areas. A water drawdown of even six to eight inches may alter the vegetation in the immediately adjacent land areas. For example, if oak trees border a field slated for irrigation, they could die -- unless the drawdown was controlled and the lowering of the water table phased to prevent a shock to the vegetative environment.

Construction of the land treatment lagoons will undoubtedly involve some lands not presently in agricultural use. This implies some disruption to "natural" biotic communities.

e. Aquatic Biotic Communities Construction of storage lagoons, in particular, will introduce aquatic communities into the rural areas. The lagoons will, undoubtedly, encourage waterfowl to visit the areas. The availability of vegetative cover as well as nearby food crops will also encourage waterfowl. The significance of these lagoons to migration and nesting patterns of waterfowl cannot be determined at this time. No such effect would be expected with the AB and PC technologies.

f. Mineral Resources Land treatment is considered beneficial relative to the AB and PC technologies, since it conserves minerals through recycling of nutrients.

Social

a. Immigration Alternative IV requires significantly fewer relocations than Alternatives III and V and is roughly equivalent to Alternative II in number of people displaced (Refer to Table E-V-5).

b. Employment Employment skills associated with land treatment are considerable and varied, ranging from sanitary engineering to farm operation and management. Some additional assessment needs to be made regarding opportunities directed at small farmers, and chronically unemployed inner city minorities. Physical synergistic thought has been demonstrated to be quite keen and welcome; we need more social synergisms particularly when attempting to explain the land treatment (or AB and PC for that matter) to the general citizenry.

c. Recreation Opportunities There is also a feeling on the part of many evaluators that land treatment areas that are in public ownership provide recreational opportunities of a type (hunting) different from urban focused recreation, if properly managed. If public access is provided, a hunting-management area would be recreationally attractive. The lands could also be adapted to wildlife management areas.

d. Community Political and Sociological Structure Obviously, the political and social impacts associated with controlling large parcels

of land (for a land system) are enormous. Provisions of corridors and the avoidance of certain areas are the major considerations illustrated in the redesign of the land system. The social-environmental evaluation team did not spend a great deal of time detailing the expected institutional impacts. These impacts will be discussed in the Institutional Evaluation report produced by another contractor of the Chicago District.

Political and social reaction to the land treatment system has been largely negative, as evidenced by numerous C-SELM public meetings.

e. Present and Potential Land Use Commercial and industrial land use within urban areas is likely to be enhanced (by incorporation of land treatment systems) with the removal of waste treatment facilities in these areas and the subsequent use of the abandoned land for commercial or industrial activities. All other possible uses should be considered before designating the land to industrial uses (e.g., urban park areas). However, land treatment requires more land than treatment plants.

Alternative IV and in part, Alternative V may have negative impacts on other than agricultural land uses in the rural areas such as the Newton-Jasper County area where the development of I-65 has opened a new path to urbanization. Prediction of a growth vector to the south in the Calumet Region was made as early as 1966. Thus, the extensive nature of land treatment suggested in Alternative IV reverses an established trend away from agricultural land use if it is to be applied to so large an area. Obviously, the I-65 right-of-way is desirable for conveyance systems, however, treatment and/or storage along this artery, especially near exits, could result in major dislocations unless properly planned. The negative values registered in the A-Matrix reflect these comments, and the fact that presently much of the land is regarded as open space and less significantly as a recreational area.

Aesthetic

Sensory quality impacts (visual and auditory) are shifted in transferring from treatment plant to land treatment; that is, the root cause of sensory quality impact in urban areas (the treatment plants) are removed from the urban area with the consequence that its impact may be lessened in rural areas due to the fact that fewer persons are affected. Obviously this does not comfort the affected rural resident. The rural resident would have to be satisfied that the impact impetus would be acceptable. Referring back to Table E-V-2, it is obvious that air emissions from the land treatment process will be minimal. However, introducing lagoons and irrigation equipment will be an obvious and possibly negative impact impetus.

Hygienic

a. Health The evaluation team has been assured by the engineering design consultant that all three treatment technologies will produce an effluent (to be evaluated later) of extremely high quality and suitable for various forms of reuse.

However, the evaluators wish to express concern over the land treatment system because of its lagoon - secondary treatment design components. These lagoons must be effectively buffered by vegetation, sealed to prevent seepage, and restricted from public access. These functional health components must be incorporated; we feel that these considerations can and will be guaranteed.

Another concern is that of mosquito control. The lagoon areas with their buffer zones provide excellent breeding areas for mosquitos. Controls should be established to minimize mosquito populations.

Economic

Although land treatment prevents large scale industrial development, it is presumed to contribute to increased farm production and income, long-range residential development and vertical growth in agro-business. Increased farm income is anticipated through increases in farm production resulting from the timed application of irrigation water, drainage control and a lowered demand for commercial fertilizers. Additional farm machinery will be necessary for land preparation and harvesting, added storage and drying facilities could be anticipated, and perhaps additional feed-lot operations would develop to take advantage of the proximity to wastewater control facilities and forage material (rye). The use of effluent nutrients will reduce the costs to the farmer with a concommitant reduction in regional income borne by fertilizer distributors and manufacturers.

Long range residential development is expected to be enhanced through the availability of access to sewage treatment facilities and through the implementation of land use controls and planning at the local level. Increased demand for housing and retail commodities will result from the increases in job opportunities created by the expected increases in agricultural production and the wastewater treatment operations.

a. Public Finance The local tax base should not be adversely affected due to payments to local governments in lieu of taxes for those lands taken into public ownership. If anything, the local tax base should be increased as a result of the attraction of new businesses and homeowners.

NUMBER OF AWT SITES, NUMBER AND LOCATION OF SITES

This section displays comments regarding the impacts of treatment processes and facilities as a function of treatment sites, both AWT and land.

Ecological

a. Air Quality One general observation of the PC process vis a vis the number of plants is that concentration of air and sensory quality degradation (through fewer PC plants) will have a more negative impact in localized areas. It is also important to recognize that PC plant locations in urban areas are in those same areas which already have severe air quality problems (e.g., SW Chicago, Calumet Harbor region, Gary, Hammond); thus the air quality problems associated with the PC processes would add to presently bad air-sensory quality conditions. In the case of AB plants this impact change vis a vis number of plants is not envisioned to be as great.

Social

a. Immigration Relocation is a significant factor with any of the C-SELM alternatives. While estimates range upwards from 15,000 to 40,000 (See Table E-V-5) a useful perspective may be shown in terms of Chicago's Crosstown Expressway which will relocate only 10,000 persons with a devestating amount of public outcry. A factor which must be considered is that equivalent, decent, safe and sanitary housing must be available at suitable locations for the relocated whether they be urban or rural people. We have been assured that planning by the Corps demonstrates realistic grappling with the relocation problem. The Corps has regulations governing relocation procedures. Some investigation of Papers and Proceedings: Commission on Third London Airport, HMSO, 1970 Vol. VII and related materials would shed additional light on some of the relocation problems and costs.

OTHER COMMENTS

Treatment Plant Technologies (Alternatives I, II, III and V

In terms of reliability, the larger plants are professed to achieve a higher degree of performance reliability, but when a large plant runs into a period of poor performance, the effects upon water quality are much more drastic. These factors, however, were not considered in the formal evaluation because it was assumed by the group under Corps instruction that there would be a constant level of performance. Evaluations could change if consideration of reliability of processes and equipment were, in fact, a part of the evaluation.

Land Treatment Technology

Since the land treatment process has not, as yet, been demonstrated to be effective at the loadings contemplated, and in an area with climate and soil conditions similar to that of the C-SELM Region, extensive pilot studies are suggested for the land and the other technologies under the same conditions of the Region before any such project is undertaken. Some evaluators feel that it is difficult, within the time allowed after briefings, to review all the information presented on land treatment and make an objective judgement.

Many questions remain presently unresolved as to the efficacy of all three treatment processes but particularly the land treatment process. However, the impending crisis in energy, water supply needs, natural resource availability and agricultural production point to the fact that future conditions may indicate that land treatment is the most desirable of alternatives. However, given the near future conditions, the lack of available knowledge, and the obvious institutional constraints involving the land treatment process, the evaluators favored Alternative V as a means by which to obtain this information without an over committment to a process that may not be as beneficial as portrayed by the engineering consultant.

SLUDGE MANAGEMENT

In this category several combinations of sludge types (conventional biological, advanced biological, land, and physical chemical) and application methods (agricultural and land reclamation) are evaluated.

BIOLOGICAL TREATMENT/AGRICULTURAL UTILIZATION

All the combinations evaluated here involve the use of biologically produced sludge (whether by conventional biological, advanced biological, or land treatment process) on agricultural lands. There is very little difference between them in our overall ratings. In particular, the agricultural utilization of sludge associated with the NDCP alternatives are judged to have very little difference in overall impact when compared to the management practices currently in use and assumed for the reference system (I).

Underlying these essentially equivalent ratings are the following arguments. NDCP biological sludges are generally considered to more greatly improve soil quality than current practices and in this respect to have a positive effect on agricultural land use. This improvement however, consumes more energy (for sludge conveyance) than current practices, and will possibly result in disruptions of access, biotic communities, and unique or rare things. On the whole, therefore, the anticipated benefits are balanced by anticipated negative impacts. The following discussion will make this clearer.

Ecological

a. Soil Quality Soil quality must be considered within the time parameter. In the near term soil quality can be expected to improve. But in the long term there may be changes in the soil's mechanical properties and suitability for agriculture. Studies are lacking regarding these long-term effects.

Land reclamation and agricultural disposal of biological sludges from wastewater treatment has already been adopted by the Metropolitan Sanitary District of Greater Chicago and the North Shore Sanitary District in Lake County, Illinois. The Gary Sanitary District already has two borrow pits (from construction of the Indiana Toll Road) for sludge disposal and these pits will be useful until 1990. Since approximately one half of the sludge from wastewater treatment in the C-SELM area is already being utilized or disposed on land sites, and since total agricultural utilization of sludges and the benefits thereof is accomplished by increased consumption of energy for sludge conveyance the evaluators rated this option overall as only a slight improvement over current practice.

b. Mineral Resources Use of biological sludges as fertilizer is regarded as a positive impact because of the mineral recycling involved.

Economic

(Note: Additional impacts will be discussed later under section dealing with potential impacts of all sludge management practices.)

a. Employment Since fertilizer would be provided from the C-SELM System, agro-business would undergo some minor changes in the affected area. This impact is not regarded significant in terms of the number of jobs lost.

b. Consumption of Goods and Services Farm machinery interests in the rural areas would benefit from increased sales of new equipment used for applying sludge fertilizer.

PHYSICAL - CHEMICAL SLUDGE/AGRICULTURAL APPLICATION

The most poorly rated combination is the agricultural application of PC sludges required by Alternative II. There are several reasons for this negative rating.

Ecological

a. Soil Quality PC sludge is suitable as a soil conditioner and effective in regulating pH. It is, however, deficient in those substances which are typically added in fertilizers, such as phosphates and nitrates, which are provided in other types of sludges.

Social

a. Community Sociological Structure Despite the argument that the greater portion of agricultural land necessary for PC sludge will be utilized but not purchased, negative responses from farmers are likely. This impact can be significant, considering the total land requirement (640,800 acres).

b. Present and Potential Land Use Because of its chemical attributes considerably more land is required for PC sludge application (nearly 641,800 acres in 1990) than for other combinations (less than 57,000 for I, about 59,000 for III, just about 58,400 for V and almost 57,000 for IV). Most of the land used is agricultural.

The reservation of this land for agriculture restricts its potential use for residential purposes thus potential residential land use is judged to be negatively affected.

The effect on other land uses is debatable. The use of vast quantities of agricultural land for sludge disposal reduces, as indicated above, the amount of land available for all other functions, a negative impact. On the other hand, this practice ensures that vast quantities of farm land will be retained in agricultural production in the C-SELM area in the future. This can produce positive impacts by providing open space and moderately positive impacts on agricultural land use by making more land farmable.

Economic

a. Energy Resources Due to the size of the distribution system for utilization of PC sludge, this sludge management scheme will require the expenditure of more energy. Therefore, the PC system is rated negatively on energy consumption relative to the utilization of biologically produced sludge.

BIOLOGICAL SLUDGE/LAND RECLAMATION

The most highly rated combination is the use of biologically produced sludge (whether by the AB or land treatment process) for land reclamation.

Ecological

a. Soil Quality There is potential for controlling acidity in strip mined areas. Soil quality in the application area is improved, possibly to the extent that it may be suitable for some types of agriculture. It may be argued, however, that sludge application to land already used for agricultural use would result in distributing benefits throughout the C-SELM Region. This is true primarily because of the wider use of sludge in agricultural utilization.

b. Mineral Resources If this method can be proven, the acceptability of surface mining for coal and other mineral resources is increased, and their availability is thus enhanced.

Social

a. Recreational Opportunities Strip mined areas when reclaimed can become useful sites for recreational purposes. For example, Shakamac State Park and Green-Sullivan State Forest in south west Indiana were once strip mined areas. Today, they provide for a wide range of recreational opportunities, including: hiking, horse-back riding, picnicing, boating, swimming, camping and fishing. Given the increasing population projected for the C-SELM region in 1990 and the anticipated increase in leisure time, there is also anticipated a need for increased recreational opportunities near the metropolitan areas. Strip mined areas that are currently unproductive could well utilize the soil building qualities of the biologically produced sludges for reclamation purposes.

b. Present and Potential Land Use The above benefits are judged in turn to favor the use of land after reclamation for residential purposes, presumably in the improved areas and those nearby.

With land reclamation, once the character of the soil has been again made productive, vegetative cover, shrubbery and trees introduced, the land becomes available for a variety of potential uses. Recreation and open space opportunities have already been mentioned. Such areas should be incorporated into local land use plans to enhance such opportunities and should lead to an orderly development for residential uses as well.

Aesthetic

Damage from strip mining includes the unsightly disruption of the land surface by the raw spoil banks and overburden. Oft times, as water seeps through these materials, it becomes acid destroying the flora and fauna for some distance down stream. The acid soil conditions prevent the establishment of adequate vegetative cover to retain the soil. This in turn creates erosion and sedimentation problems in the area which increases the likelihood of floods, destroys property values, and in general produces a very blighted landscape similar to that of the moon. Land reclamation through improvement of soil quality, landscaping, and the reinstitution of a vegetative cover produces a much more acceptably pleasing aesthetic environment.

Economic

a. Energy Resources A negative impact of this combination is the consumption of considerably more energy to transport the sludge the greater distances inherent in this option than required by the other sludge management options (other than the PC sludge utilization discussed earlier).

This negative impact is heavily outweighed by the number of benefits which should accrue because of land reclamation.

IMPACTS ASCRIBED TO ALL FORMS OF SLUDGE MANAGEMENT

Ecological

a. Surface and Subsurface Water Quality Biologically produced sludges contain considerable amounts of organic material, metal ions, phosphates, nitrates and lime. Overland runoff and subsurface seepage emanating from the sludge areas could introduce significant amounts of these "pollutants" into the area drainage and groundwater if uncontrolled. Good management practices can eliminate this possibility. As is discussed above, the use of biologically produced sludges for land reclamation can result in a substantial improvement in strip mined areas. With the control of acid soil and water conditions and the establishment of vegetative cover new terrestrial and aquatic biotic communities will be established.

b. Mineral Resources Biologically produced sludges contain substantial amounts of nutrient materials, lime, phosphates, nitrates and organic matter. Such sludges when applied to the soil act as fertilizers and soil conditioners lessening the demand for commercially manufactured and distributed fertilizers. This in turn results in a conservation of mineral resources.

Social

a. Present and Potential Land Use Use of certain sites, such as the Porter County site in Indiana, for sludge disposal when they are particularly suitable for residential use is ill-advised. Many such areas can more readily absorb development without depreciation of environmental quality than others; these should not be utilized for sludge disposal.

Aesthetic

a. Odors There may be undesirable odors and unsightliness associated with these practices over which management and design controls may be needed. If the sludges are adequately treated and stabilized there should be no problem.

Hygienic

Sludges may contain significant concentrations of toxic chemicals, heavy metals and nitrates. Excessive nitrate and nitrate infiltration into well water and its subsequent use for domestic supplies can lead to a blood disorder, methemoglobonemia. High concentrations of heavy metals can under certain conditions create phyto-toxic conditions in certain plants grown on sludges. These could potentially be concentrated through the food chain. Adequate monitoring and evaluation should limit this possibility.

WATER REUSE

Comments in this category are related to reuse flows provided for recreational, navigational and potable needs. They reflect (1) impacts arising from the two major reuse options, i.e., limited or unlimited use of Lake Michigan water for potable needs, and (2) impacts attributable to the differences between alternatives in the transportation of reuse waters to need centers.

OPTION I - REUSE OF TREATED EFFLUENT WATERS

Major positive impacts would accrue in the C-SELM region as a result of the implementation of the reuse of treated effluent waters.

Ecological

a. Surface Water Quality and Quantity Alternatives II through V were viewed as having substantial positive impacts in reducing flooding and in improving surface water quality.

A significant part of the increased water quality and temporal and spatial redistribution of runoff flows, however, arises from the collection, storage and treatment of rural and suburban stormwaters. Benefits considered in this category (Reuse of Treated Effluent Waters) are due primarily because the flows are adequately distributed to streams and the water quality is equal to NDCP standards.

b. Terrestrial Biotic Communities Biotic communities, along with unique and rare things may be negatively affected as increased regionalization of treatment facilities and processes reduces the number of plant sites and, conversely, increases the amount of pipeline construction necessary to transport reuse waters to the headwaters areas of need centers. The negative aspect of these disruptions would be outweighed by the positive effect on aquatic biotic communities and unique and rare things expected if NDCP reuse water rather than Reference Plan reuse water was returned to the streams. There is however, a strong consensus among evaluators preferring alternatives approximating "natural" conditions, i.e., stream reuse versus pipeline reuse. High quality water distributed surficially throughout the C-SELM region

would accrue benefits to more people and eco-systems over wider areas than the pipeline option of Alternative II through V because of disruptions caused by pipeline construction.

c. Aquatic Biotic Communities Improvements in water quality will be reflected in aquatic organisms. Removal of organic loadings, turbidity, toxicants, and the improvement of the dissolved oxygen concentration of the water will result in clean water organisms reinstating themselves. Anticipated improvements in stream conditions would encourage repopulation of clean water benthic communities (e.g., midge larvae, snails, clams, mayfly nymphs, leeches, etc.). These in turn would provide a food base to reestablish higher quality fish species (e.g., largemouth bass, crappies, bluegills, etc.).

d. Terrestrial Biotic Communities No major improvement of the terrestrial ecosystem is expected other than that resulting from stormwater management.

Social

a. Immigration Improvements in water quality and quantity in the C-SELM area could result in encouraging more immigration into C-SELM.

b. Present and Potential Land Use Residential activity will be beneficially impacted by providing a cleaner and more attractive environment in C-SELM, particularly near streams.

c. Recreational Opportunities Recreational opportunities are expected to be enhanced in that swimming conditions and sport fishing opportunities should improve. The recreational value along the streams (hiking, picnicing, etc.) should likewise appreciate.

Aesthetic

Changes in water quality will be characterized by clearer, comparatively odorless and cleaner streams. Aesthetic appreciation should be obtained from the repopulation of clean water organisms such as sport fishes, aquatic plants, etc.

Hygienic

The reduction of bacteria, viruses, toxicants and other pathogens will have a limited although positive hygienic impact. The main reduction in pathogen count is due primarily to the treatment of both separate and combined stormwater, and adequately sized facilities to treat all dry weather flows. The reuse of treated effluent for potable supply is not assumed to have any negative hygienic effect since this water would be treated to USPHS standards. There would probably be a negative psycological reaction to the use of wastewater for potable supply at least initially.

Economic

a. Energy Resources A generally negative impact to power consumption and materials resources was ascribed to alternatives involving greater regionalization and, therefore, greater pipeline construction and use of energy to operate this portion of the C-SELM systems.

OPTION II - UNRESTRICTED USE OF LAKE MICHIGAN WATER FOR POTABLE NEEDS

There are serious water supply problems in the Illinois portion of the C-SELM region due not to a scarcity of water, but to legal and institutional difficulties. The pressure to solve these problems is immense and they will probably be solved whether or not any of the C-SELM study alternatives become proposals and are adopted or not.

Due to limitations in time and budget constraints, as well as the intent of this social-environmental analysis, the institutional (legal) aspects of Lake Michigan diversion were not considered.

Indeed no clear-cut consensus of opinion exists among evaluators' comments concerning increased use of Lake Michigan waters for potable needs. Unfortunately, we could not adequately address the following questions: What effect would the removal beyond the 3200 CFS limit have on lake levels? Would such a restriction's removal, as the result of C-SELM set a precedent throughout the Great Lakes basins resulting in drastically increased removal of large quantities of lake waters for potable and other needs? Why not use the reuse waters from wastewater treatment systems for potable needs either as part of groundwater recharge or as a surface supply?

We do offer the following opinions: The use of additional Lake Michigan water would require a significantly greater use of energy for pumping plus increased pipeline construction in addition to that already involved in transporting reuse water to need centers for navigational and recreational uses. As stated earlier, this pipeline construction would have a negative impact on biotic communities, unique and rare species, and materials and energy resources.

Conversely, the unrestricted potable use of Lake Michigan water is an excellent way to meet the demands for clean water as long as wastewater of good quality is returned to maintain Lake Michigan's water level. It is a better systematic procedure in that less treatment chemicals such as coagulants and chlorine are required to process the water than would be the case in utilizing reuse water. The evaluators recognize that should the treated wastewater be returned to Lake Michigan TDS (Total Dissolved Solids) would increase. The evaluators perceived no significant negative impacts over the near term. Long term effects on aquatic biota were unclear at the concentrations projected.

POWER SYNERGISM

The analysis of the potential power synergism did not follow the pattern established in the analysis of other functional system components. The evaluation team approached the power synergism as only a potential add-on feature to a land treatment system. The power synergism was not considered as a definite design feature of land treatment systems. The following discussion, therefore, does not detail a complete impact analysis of the effects of placing a power plant in a land treatment area.

1. Power plant siting is a definite problem in the C-SELM region. One evaluator who has done considerable consulting for the power companies in the area offers the following opinions. There are two power plant sites on Lake Michigan in Illinois and these are probably the only ones which will ever be used. There are at present four power plant sites on Lake Michigan in Indiana and the possibility of two more, but there is great resistance to the development of these sites or to expansion of power generating facilities at existing sites by conservation and environmental groups. Truly, the shoreline in the C-SELM region has become a zone of land use conflict and competion.

2. With the completion of the power plant(s) on the Kankakee River in Jasper County, Indiana, it appears that sites on streams within or close to the C-SELM region are about fully exhausted. Additional electrical power supplies for the C-SELM region most likely are to be developed outside the region. The power plant sites being developed nearby but outside the C-SELM region which have cooling ponds include the Dresden Station (1250A), LaSalle County Station (4480A) Powerton, and Braidwood Station (4800A). Thus very large cooling ponds at power plant sites may be developed independently of the C-SELM study wastewater management alternatives.

The use of wastewater storage ponds for cooling ponds for large power plants could have important benefits if they are designed and operated properly. They could also be an environmental nuisance if they were done improperly.

Power generation in conjunction with the land treatment alternatives (IV and V) has moderately positive impacts when compared to the siting of equivalent facilities elsewhere within the C-SELM region. Thus, although power production itself has some inherently negative environmental impacts it is viewed as being less negative when located on dispersed, inland sites rather than elsewhere in the C-SELM region. Their inland location seems, in this respect, preferable to the continued expansion of electric generating capacity along the Lake Michigan shoreline for example. These proposals for storage lagoon siting would positively affect the surface water quality of the area inasmuch as thermal effects would be limited to closed systems rather than sites on open streams or in Lake Michigan.

Sensory quality of the environment also would be positively affected in C-SELM because plants so sited would be away and/or shielded from most populated areas. Thus, the power synergisms in alternatives IV and V present a far more efficient use of land and water resources and provide additional options for power plant site selections and reduce the need to find additional sites along the lakeshore or on streams within or outside of the C-SELM region as would be the case in Alternatives I, II, or III.

Since an additional 20,000 MW by 1990 and 55,000 MW by 2020 of electrical generating capacity are required, the power plant synergism of Alternatives IV and V will result in positive impacts on sensory quality of the environment, surface water quality, recreation and open space, biotic communities, and rare and unique things especially along the Lake Michigan shoreline which can benefit from the lessened competition for land between public utilities and recreation and conservation interests. The total future energy requirements suggested above may be met by the land treatment alternatives through the power synergisms using a lesser total generating capacity than that needed for the other alternatives because they can provide power during peak load periods <u>via</u> the implementation of pumped storage generation.

The concept of joint siting of power producing facilities within the land treatment areas would have a positive impact upon the tax base of the rural areas. Additional employment opportunities would result and this in turn would increase residential activity.

However tempting from a traditional point of view these power synergisms may be, they could encourage a greater concentration of generating facilities than is necessary for local needs at the same time putting greater stresses on the environment. Further concentration of pollution emitting sources than is necessary in an already heavily impacted area should be avoided. Not enough design information about how the wastewater storage ponds would be used for cooling power plants was provided for a full evaluation of the ecological and social consequences.

MANAGEMENT OF MINED ROCK

All C-SELM study alternatives involve large quantities of mined rock and soil, much of it originating in the urbanized portion of the region. Comments in this category pertain to the possible uses of these earth resources for commercial, reclamation and recreation purposes. These management practices for these materials are offered for potential design consideration, should a C-SELM alternative, or parts thereof, be incorporated.

COMMERCIAL OPPORTUNITIES

This particular aspect of the C-SELM study has received the least attention in terms of its synergistic possibilities. Doubt exists concerning the 1990 and 2020 supply and demand situation for place-value, non-metallic mineral resources in the C-SELM region. Studies show urbanization results in the "building over" of an urban areas's mineral resources. Chicago is no exception. It is doubtful that more than a few Silurian reef structures remain with thin overburden to be developed as quarries in the C-SELM region. The Indiana portion of C-SELM has no supplies of gravel and must rely on crushed stone from quarries for its source of aggregate. The Port of Indiana used rock transported over 200 miles in the construction of its breakwaters.

With these facts and examples in mind, it seems unwise not to consider the dolomite mined during tunneling and lagoon development as a potential economic commodity. Therefore, significant future resources of crushed and dimension stone should be reserved for the future growth of the megalopolis.

RECLAMATION OPPORTUNITIES

Knowledge of the C-SELM region's land use history reveals that much of the area is a reclaimed wetland, the Calumet Lacustrine Plain. This area, once the bottom of Lake Michigan, was only recently and, indeed, is only now, being drained. It contains many low marsh and bog areas. Over the past 100 years sand has been mined from dunes and pits to fill in low regions for the urbanization of greater Chicago. Much of the Chicago lakefront consists of fill from the Indiana shoreline dunes.

This process continues today. It is inconceivable that a proposal to construct a mountain from mined rock can be presented while "mountains" of sand dunes are being mined for landfill purposes. A high priority for mined rock and soil should be the use for landfill purposes. The practice of sand-pit mining is extensive and results in many hazardous water-filled sand mines. Priority for reclamation uses of mined rock and soil should involve the following in the C-SELM region:

1. Use of fine-grained sediment as cover material in sanitary landfills where only coarse cover is now available.

2. Filling of sand mines which have become health and safety hazards.

3. As a fill material in place of sand in order to preserve the remaining sand dunes of the region.

The three reclamation alternatives suggested in this study (Creation of a recreational hill in south Cook County, creation of a chain of islands in Lake Michigan, and other open space landscaping) should be considered only after the above-mentioned needs have been satisfied and a better knowledge of shoreline processes in Lake Michigan exists.

RECREATIONAL OPPORTUNITIES

Such development should only be considered after all needs for commerce and reclamation have been satisfied. The mountain concept presented by the Corps design consultant (for costing purposes) should be considered in conjunction with an area-wide solid wastes disposal program--a massive sanitary landfill plus mined rock landscape.

Introduction of the "islands" proposal at this stage of the study hardly provides the evaluators with the information necessary for any cogent assessments. While this synergism appears possible, the social and environmental impacts go well beyond the scope of this study.

ANNEX A THE IMPACT OF ENVIRONMENTAL PARAMETERS ON HUMAN ACTIVITIES - AN ANALYSIS OF THE B MATRIX

The methodology permitted a generalized evaluation of the impact of changes in the environment on human activities. This evaluation was based on a potential increase or enhancement in each environmental condition, and was assumed to be independent of the specific wastewater treatment system element which might affect the environment. The generalized impact relationships in the B Matrix could thus be used to transmit the environmental impacts of any alternative wastewater management system to a wide range of important human activities.

For example, the evaluators were asked to estimate the probable impact of a hypothetical enhancement in water quality on residential activity. On balance, the evaluators judged that impact to be moderately positive. This information provides a way for the impacts of wastewater system elements on water quality (from Matrix A) to be understood in terms of the impact on residential activity. If a system element results in a large positive improvement in water quality, the impact on residential activity is expected to be rather large. Since an improvement in water quality in general is expected to have moderately positive consequences for residential activity, a large increase in water quality (generated by a wastewater system element) is expected to have a relatively larger positive impact on residential activity. Similarly, any wastewater system element which leads to a deterioration in water quality will adversely affect residential activity in proportion to the extent of the deterioration in water quality.

Thus, the evaluation embodied in the B Matrix provides a shorthand method of measuring the impacts of the wastewater system elements on the environmental parameters in terms of their impacts on human activities.

This general evaluation, of course, represents the pooled judgments of the evaluators. Disagreements over direction and magnitudes naturally exist, and the major disagreements are noted below.

Table E A-1 displays the B Matrix evaluation in symbols. The primary impact categories (the environmental parameters) are each designated as rows. The impacts of the environmental parameter on each human activity are described in the appropriate column. A large circle indicates that the impact was judged to be large and positive. A small circle indicates a moderate positive impact. The shaded circles indicate negative impacts.

WATER QUALITY AND QUANTITY

An improvement in surface water quality is judged to result in a large improvement in recreation, the aesthetic quality of the environment, and ecosystem status. Moderate improvements in health and safety, food production and residential activity are also expected to result from any enhancement of surface water quality. Indeed, improvements in surface water quality were considered to have only beneficial impacts on human activity.

Some of the positive impacts of improvements in surface water quality on human activities are the secondary effects of the direct impact of surface water quality on intervening activities. For example, the large improvement in water-related recreational activity that is a consequence in the improvement in surface water quality is assumed to result in an improved and attractive residential environment. A more attractive residential environment in turn, results in immigration to the C-SELM area. (1)

The improvement in surface water quantity (availability), as in the case of water quality, is viewed as having a strong positive impact on human recreational activity. Improvements in surface water availability, without a similar improvement in water quality, are viewed as not having as extensive favorable impacts on aesthetics and ecosystem status as improvements in water quality alone. This difference, however, does not exist with regard to improvements in residential activity. The uniformly moderate impacts on residential activity are probably the indirect effect of surface water quality and quantity on recreational activity and aesthetic activity.

Additional surface water does have a moderate positive effect on industrial and food production. As in the case of improvements in surface water quality, the greater availability of surface water was viewed as having only beneficial effects on human activities.

Improvement in subsurface water quality is seen as somewhat beneficial to residential activity and health and safety. Improvement in subsurface water quantity is expected to lead to moderate improvements in industrial and food production and residential activity. As in the case of surface water, enhancement of subsurface water resources was viewed as having only beneficial effects on human activities, especially residential activity. (2)

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(1) It should be noted here, however, that the B Matrix describes the probable result of small changes in environmental characteristics on each human activity. An extremely large environmental change might reverse the effect on human activities. If, for example, a large improvement in recreational land use created congestion, then the effect of this congestion on residential activity might become negative. In general, this evaluation assumed that any changes in the environmental parameters would not drastically depart from the reference condition.

(2) Here again a very large shift from existing conditions could change the expected impact. For example, too much residential activity could itself create a negative impact on subsurface water, through faulty septic tanks.

AIR AND SENSORY QUALITY ON THE ENVIRONMENT

The evaluators judged that improvement in air quality would have larger positive impacts on human activities than any of the other environmental parameters. Improvements in air quality are expected to make large contributions to the enhancement of residential activity, health and safety, and aesthetic activities.

The close relationship between air quality, the sensory quality of the environment and aesthetic activities resulted in high impact scores in the evaluation. Improvements in air quality and the sensory quality of the environment resulted in very large improvements in aesthetic activities.

Naturally enough, it was felt that improvements in the aesthetic environment strongly enhanced residential activity, which in turn would influence immigration to the C-SELM area. Moreover, improvements in air quality were judged to have strong positive effects on health and safety and ecosystem status. Recreation activities were also expected to be significantly enhanced by improvements in air quality and the sensory quality of the environment.

LAND USE

The evaluation of the impact of changes in land use on human activities confirms the competing nature of land use demands in the C-SELM region. If more land is allocated to present or future residential use, residential activity would be enhanced at the expense of food production. If more land is diverted to industrial or commercial use, production in these sectors would increase, but the amount of available land for food production and residential activity would decrease. Similarly, a greater share of the region's land resources devoted to agriculture would increase food production while commercial, industrial, and residential activity would suffer in terms of available land. Finally, if land is set aside for recreational purposes, recreational activity would be enhanced at the expense of commercial, industrial and agricultural production and residential land use. The B Matrix evaluation scores thus provide an indication of the relative opportunity costs of allocating land among competing activities. The scores provide a measure of the extent to which some human activities must be foregone in order to achieve the enhancement of a particular activity. The overall social impact of a reallocation of land depends on how society values each of the activities that use land.

The direct trade offs between competing land use allocations are complicated by the further direct and indirect effects of increasing the share of land allocated to a particular activity (and hence decreasing the share available to other uses). For example, the enhancement of residential activity would lead to immigration into the region, and an increased

TABLE EA-1

IMPACT OF PRIMARY DIMENSIONS ON HUMAN ACTIVITIES

Average B Matrix

Human Activities

Impact Scale Key

-1.0 to -1.9	●
-2.0 to -3.0	⬤
+1.0 to +1.9	○
+2.0 to +3.0	◯

For all other cells, the impact ranges from -0.9 to +0.9

Primary Impact Dimension	1 Commercial Production	2 Industrial Production	3 Food Production	4 Construction Services	5 Public Service	6 Private Service	7 Residential Activity	8 Immigration	9 Population Density	10 Health & Safety	11 Employment	12 Income	13 Cultural-Education	14 Public Finance	15 Recreation	16 Aesthetic	17 Ecosystem Status	18 Community Political Structure	19 Community Social Structure
1 Surface Water Quality			○				○			○					◯	◯	◯		
2 Surface Water Quantity		○	○				○	○			○				◯	○	○		
3 Ground Water Quality			○				○			○							○		
4 Ground Water Quantity		○	○				○	○											
5 Air Quality							◯	○	○	◯		○	○		○	◯	○		
6 Sensory Quality							○	○		○					○	◯	○		
7 Residential Land Use				○	○	○	◯	○	○										
8 Commercial & Industrial LU	◯	◯		○		○					◯	○		○	●	●	●		
9 Agricultural Land Use			◯					●	●								○		
10 Recreation & Open Space							○			○			○		◯	◯	○		
11 Soil Quality			◯														○		
12 Mineral Resources		◯		○							○								
13 Energy	○	◯		○	○	○	○	○	○			○							
14 Access	○	○	○	○	○	○	○	○			○	○	○	○	○	○			
15 Biotic Communities													○		○	○	◯		
16 Unique or Rare Things													◯		○	○	○		

demand for construction and public and private service. On the other hand, more housing developments could be destructive to ecosystem status.

The increase in industrial and commercial production that results from greater land use allocation to these activities generated the largest negative impact scores in the B Matrix evaluation. In addition to reducing residential and agricultural activity, a greater amount of commercial and industrial activity would be disruptive of recreation and aesthetic activities, the ecosystem status, and the social structure. The general level of health and safety and cultural and educational activities were also judged to suffer. On the other hand, greater industrial and commercial activity would result in more construction and higher income and employment. The greater availability of jobs would attract more people to the region, but most of the potential immigration would be choked off by the adverse impacts on human activities that accompany greater industrial and commercial production.

While the allocation of more land to food production was judged to enhance recreational and aesthetic activities and ecosystem status, it would result in negative impacts on more human activities than any other environmental change. Community political and social structures would be disrupted. (3) The decline in residential activity that results from an increased land use allocation to food production would in turn impact negatively on construction activity. The latter, together with the diminished commercial and industrial production that follows constrained land use for those activities, would result in lower employment in the C-SELM region. All of these factors would combine to diminish the demand for private services, and discourage immigration into the region. The new land use pattern would also create public finance difficulties, but it would tend to disperse the population more thinly over the region.

Increased recreational land use would enhance aesthetic activities and the ecosystem status. On the other hand, the indirect effect of enhancing recreation at the expense of industry and commerce would be a small decline in construction and a smaller fall in income in the region. Residential activity would be slightly enhanced, as would cultural and educational activity. Finally, the evaluators expect that the improvement in safety associated with the decrease in production and construction activity would more than offset the accidents associated with increased recreation.

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(3) The evaluators defined impacts that would result in <u>changes</u> in political and community structures as negative; those that would stabilize those structures were rated on the plus side. Because of difficulty with this assumption, the average scores were all small. Only <u>two</u> minus scores resulted for community structures (as impacted by commercial and industrial land use, and agricultural land use), and only <u>one</u> for political structures (as impacted by increased <u>agricultural</u> land use allocations).

SOIL QUALITY

This factor is important for food production, as recognized by the evaluators. Again there are other effects, as well. With improved soil quality ecosystem status and aesthetic qualities were expected to be enhanced.

However, it should be kept in mind that there are many unanswered questions about the properties of soil. Thus, improvement in soil quality by the land treatment method is still uncertain from a long range point of view. The evaluations took a 50 year point of view and judged the impact of improvements in soil quality as enhancing human activities.

Another long range phenomenon that must be considered is the feedback effect of utilizing improved soil for food production, residential or recreational uses. Extensive use may wash out the effects of initial improvements.

MINERAL AND ENERGY RESOURCES

Increased availability of mineral resources and energy, either through increases in the supply of or reduced demand for these resources, is viewed as having a large favorable impact on industrial production and moderately favorable impacts on construction activity. The greater availability of these resources does not result in uniform enhancement of all human activities, however. Greater energy and mineral resource availability is judged to have detrimental effects on ecosystem status, directly through production and indirectly through its effects in stimulating industrial and construction activity.

The increased availability of mineral and energy resources has positive indirect effects on employment and income through the effect of resource availability on production. The greater availability of energy in the C-SELM region is also viewed as beneficial to commercial activity, the provision of public and private service, and residential activity. The impact of greater energy availability on production and residential activity has spillover or fallout effects on other human activities. Enhanced residential activity and the greater availability of employment and income opportunity attracts newcomers to an area, and hence increases the rate of immigration. It should be recognized, however, that extreme immigration into the C-SELM area might have negative social impacts.

The evaluators judged the resulting mix of production and residential activities to be somewhat beneficial for the problems of public finance in the region. It should be recognized, however, that increases in income and employment due to the greater availability of mineral resources imply declines in aesthetic activity and long-run residential activity (after an initial increase), and negative impacts upon recreation, health and safety, and the community socio-political structure.

ACCESS

Improvements in access are important determinants of population shifts, recreation and residential activities, and commercial, industrial, and food production. In addition, they produce second order effects in the area of population density, employment and income, aesthetics, and even education and cultural activities. The community socio-political structure is also affected in the long run. (4)

The evaluators recognized the impact of access across the whole range of human activities. Improvement in access was expected to also lead to greater construction activity and the enhancement of public and private services. Population density was judged to be only weakly affected by by improved access. No doubt the positive increase in population density by means of greater access to the suburbs.

On the negative side, improved access was judged to be a threat to ecosystem status. Regarding the aesthetic quality of the environment, a net "no effect" resulted. This is due to a balancing of slightly negative and slightly positive views regarding impacts. Studies show short-run benefits, but long range negative impacts if firm planning and land use controls are not exercised at access points. (5)

BIOTIC COMMUNITIES AND UNIQUE OR RARE THINGS

Preservation of historical sites, aesthetically desirable natural features (e.g., wooded areas, dunes, streams) and wild life is viewed as offering constraints on socio-economic development. The evaluators judged these constraints to have only minor negative impacts on commercial, industrial and food production (6) and construction activities. However, a concentrated effort for the preservation of unique or rare things in the C-SELM area might impose considerable constraints on such activities. For example, preservation of the national lakeshore might severely limit the expansion of steel production there. Further, air quality controls have already cut into possible production levels or profitability of existing plants.

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(4) See, for example, John R. Maiolo, ed., Highways and Communities (Pennsylvania State University, Institute for Research on Land and Water Resources, Summer 1966).

(5) See Blairsville: A By-Pass Study (Pennsylvania State University: Institute for Research on Land and Water Resources, 1962; and Munroeville: The Social and Economic Impact of a Highway (Pennsyl-State University, Institute for Research on Land & Water Resources, 1958).

(6) Preservation of biotic communities was viewed as having a positive effect on food production.

On the other hand the evaluators perceived somewhat stronger positime impacts of preserving unique or rare things on recreation, aesthetic activities and ecosystem status. Spillover benefits also exist in the area of cultural and educational activities. Given the tradeoffs between production and other human activities associated with the preservation of unique or rare things, the social weight or priorities assigned to each human activity are crucial in determining whether the overall impact of preserving unique or rare things is positive or negative. With regard to this variable, then, the region is faced with a difficult policy choice. Some optimal combination of the preservation of our natural resources and minimum production levels must be found.

WEIGHTS OF HUMAN DIMENSIONS

The following table indicates the evaluation team's weighting of the human factors. This rating on a scale from -3 to +3 indicates the evaluator's judgments of the relative desirability of enhancing the activities indicated. In other words, given the current status of these activities within the C- SELM region, it was felt that society would benefit from improvements in the areas of aesthetic activity, health and safety, ecosystem status, recreation, and cultural and educational activities relative to the remaining activities.

It should be emphasized that this ranking reflects the judgments of the evaluation team. Other rankings have been used which produce slightly different (but very interesting results). (See Chapter 4, Table 3 and Figure E IV-3).

TABLE E A-2

HUMAN FACTORS WEIGHTS

Factors	Weights
Aesthetic	2.8
Health and Safety	2.7
Ecosystem Status	2.5
Recreation	2.4
Cultural/Educational	2.4
Public Service	2.1
Employment	2.1
Public Finance	1.9
Income	1.7
Commercial Production	1.7
Food Production	1.6
Private Service	1.3
Residential Activity	1.3
Community Social Structure	1.1
Construction Services	.8
Community Political Structure	.7
Industrial Production	.6
Immigration	-1.5
Population Density	-1.9

TABLE E A-3

H-VECTOR WEIGHTS

HUMAN DIMENSIONS (H Vector)	HUMAN DIMENSIONS WEIGHTINGS: Evaluation Team 2nd round	Evaluation Team 1st round	Commerce & Industry Committee	Planner & S.D. Official
Commercial Production	1.7	1.2	1.3	0.5
Industrial Production	0.6	0.3	1.7	1.0
Food Production	1.6	1.0	2.0	0.5
Construction Services	0.8	0.8	0.5	0.7
Public Service	2.1	2.3	1.0	1.5
Private Service	1.3	2.0	0.2	1.0
Residential Activity	1.3	1.5	0.8	1.7
Immigration	-1.5	-0.2	-1.0	-1.0
Population Density	-1.9	-1.2	0.0	1.7
Health and Safety	2.7	2.8	2.3	2.0
Employment	2.1	2.2	1.5	-1.0
Income	1.7	1.8	1.5	0.5
Cultural-Educational	2.4	2.5	-0.3	0.0
Public Finance	1.9	1.8	1.5	2.0
Recreation	2.4	2.5	0.8	1.8
Aesthetic	2.8	2.5	0.8	1.3
Ecosystem Status	2.5	2.8	0.8	0.7
Community Political Struc.	0.7	0.5	1.2	1.0
Community Social Structure	1.1	1.3	-0.8	0.5

ANNEX B: DISPARATE POINTS OF VIEW AMONG THE JUDGES

INTRODUCTION

The results presented in Sections III and IV of this report are based on the assumption that the best estimate of impact in any given cell of the A or B matrix is the average of the estimates of the individual judges. The averaging approach is reasonable if each judge randomly samples his estimate for a given cell from the same normal distribution with expected value equal to the "true" impact coefficient and with its variance being the result of random errors of judgment. In such a case we would have theoretical agreement on concensus among the judges.

However, it is doubtful that this argument applies here. The primary reason for utilizing a multi-disciplinary panel of evaluators is to allow impact to be examined in terms of a spectrum of specialized points of view. It is not likely that any one person can effectively comprehend the whole picture, and it is therefore not likely that differently trained specialists will agree, even if their judgments are error-free. Each judge will tend to view the impacts through the eyes of his own discipline. He will be sensitive to certain specialized facts, processes and criteria, while neglecting others that are less relevant to his concerns. Such disagreement among judges about impacts does not necessarily mean that anyone is wrong; rather it means that each has examined a different, though perhaps over-lapping, set of channels of impact. The impacts assessed in this way must be assembled into a mosaic of the total impact, almost as one would assemble a puzzle. If we assume (1) that the impacts are additive, (2) that all important channels of impact are equally represented among the panelists, and (3) that errors of judgment are random and relatively small, the average is a good estimate of the overall or composite impact for any given cell in the matrix.

Yet, there are several important reasons why we ought to look beyond the averages into an analysis of individual viewpoints:

(1) to determine whether there are in fact disparate points of view among the judges or whether observed disagreements can be attributed to random errors.

(2) to determine whether the different viewpoints, if differences exist, are represented equally in the panel.

(3) to describe the different points of view and to explain the impacts as seen by each, and

(4) to assess the relative credability of the different points of view, if possible.

It is the purpose of this section of the report to analyze and discuss

TABLE EB-1

SYSTEMS AS SCORED BY INDIVIDUAL PANELISTS

System	Type	Gemmell	Hermann	Schofer	Pipes	Peterson	Watson	Kinias	Kehrer	El Naggar	Reshkin	Krekeler	Maiolo	Cypra	Avg. (Avg. "A" x Avg. "B" x Unit "H")
1	I	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2		203.0	605.0	37.0	-645.0	69.0	-22.0	5.0	-140.0	-137.0	-429.0	-207.0	-414.0	-94.0	-47.9
3	II	183.0	545.0	50.0	-778.0	91.0	-22.0	87.0	-24.0	-193.0	-364.0	-99.0	-327.0	-79.0	-28.3
4		247.0	993.0	143.0	-223.0	130.0	36.0	-125.0	3.0	178.0	-152.0	-245.0	-112.0	-15.0	91.7
5	III	227.0	933.0	156.0	-356.0	152.0	36.0	-43.0	119.0	122.0	-87.0	-137.0	-25.0	0.0	111.3
6		404.0	1068.0	136.0	-201.0	151.0	59.0	9.0	-43.0	335.0	380.0	-253.0	9.0	73.0	182.5
7		384.0	1008.0	149.0	-334.0	173.0	59.0	91.0	73.0	279.0	445.0	-145.0	96.0	88.0	202.1
8		395.0	-66.0	144.0	-697.0	114.0	20.0	-170.0	-11.0	198.0	-830.0	-165.0	212.0	-59.0	-29.5
9		375.0	-126.0	157.0	-830.0	136.0	20.0	-88.0	105.0	142.0	-765.0	-57.0	299.0	-44.0	-9.9
10		475.0	-92.0	271.0	-771.0	259.0	64.0	-168.0	60.0	356.0	-1026.0	16.0	212.0	-126.0	24.1
11		495.0	-152.0	284.0	-904.0	281.0	64.0	-86.0	176.0	300.0	-961.0	124.0	299.0	-111.0	43.7
12	IV	532.0	-36.0	150.0	-756.0	157.0	56.0	26.0	86.0	427.0	-212.0	-65.0	477.0	44.0	85.1
13		552.0	24.0	137.0	-623.0	135.0	56.0	-56.0	-30.0	483.0	-277.0	-173.0	390.0	29.0	65.5
14		612.0	-62.0	277.0	-830.0	302.0	100.0	28.0	157.0	585.0	-408.0	116.0	477.0	-23.0	138.7
15		612.0	-2.0	264.0	-697.0	280.0	100.0	-54.0	41.0	641.0	-473.0	8.0	390.0	-38.0	119.1
16		262.0	106.0	163.0	-525.0	147.0	15.0	-108.0	-7.0	44.0	-253.0	-306.0	226.0	67.0	43.7
17		242.0	46.0	176.0	-658.0	169.0	15.0	-26.0	109.0	-12.0	-188.0	-198.0	313.0	82.0	63.3
18		325.0	216.0	223.0	-595.0	210.0	50.0	-84.0	-27.0	-12.0	-347.0	-125.0	442.0	42.0	89.6
19	V	305.0	156.0	236.0	-728.0	232.0	50.0	-2.0	89.0	-68.0	-282.0	-17.0	529.0	57.0	109.2
20		419.0	188.0	156.0	-451.0	168.0	51.0	6.0	4.0	353.0	250.0	314.0	285.0	-162.0	141.7
21		399.0	128.0	169.0	-584.0	190.0	51.0	88.0	120.0	297.0	315.0	-206.0	372.0	177.0	111.3
22		482.0	298.0	216.0	-521.0	231.0	86.0	30.0	-16.0	297.0	156.0	-133.0	501.0	137.0	181.6
23		462.0	238.0	229.0	-654.0	253.0	86.0	112.0	100.0	241.0	221.0	-25.0	588.0	152.0	207.2

Evaluation Panelist

the disparate views of the panelists. This will allow the analyst to make corrections or adjustments in the average results, while allowing the reader to use his own judgment in deciding which viewpoints are most relevant to him.

EVIDENCE OF STABLE DISAGREEMENTS AMONG THE JUDGES

Analysis of variance of the A and B matrices leads to the conclusion that the cell averages are far more reliable than could be expected if the observed disagreement among judges were purely random. For example, in two independently estimated average B matrices (summer 1972 and winter 1973) differences between the matrices constitute only 3% of all the information these contain. This means that these are 97% reliable. The average among-judge variance predicted by this result is 0.430 (a predicted standard deviation of 0.656). The observed average variance among judges for any given cell is much greater, 1.26, (actual standard deviation of 1.12). Thus, the difference between 0.430 and 1.26 must have been caused by stable disagreement among judges.

Similar conclusions can be drawn about the A matrix, although there is less observed disagreement among the judges than in the B-matrix (actual among-judge variance - 0.842). The presence of stable disagreement means that different viewpoints are being expressed. Different panels might produce different average matrices, and it is important to isolate the disparate views expressed by the panelists we have used.

THE SYSTEMS AS SCORED BY EACH INDIVIDUAL JUDGE

If the individual's A matrix is multiplied by his B-matrix, the product is an individual C-matrix. When this C matrix is multiplied by the unit weighting vector, the resulting row sums are system element scores from the individual judge's point of view. Combining the appropriate system element scores into system scores produces the information shown in Table EB-1, overall system impacts as seen by each judge. The range of variation is shown in Figure EB-1. Clearly, there are major differences among the thirteen judges. These differences may be divided into two categories: (1) range of variation, and (2) relative ordering among systems.

The following paragraphs briefly verbalize each judges way of evaluating the systems. The approach used in the narrative is first, to state the order of preference for treatment types under the assumption of equal options (i.e., agricultural sludge disposal, potable needs from Lake Michigan, and no power, the options common to all five system types, including the reference system). Second, exceptions to this ordering are described as they result from the effect of other options. Third, systems having net positive and net negative impacts relative to the reference system are identified by treatment type and combinations of options. Fourth, the judges' preferences between pairs of options (e.g., power vs. no power) are described where the pattern is consistent. Finally, a statement is made

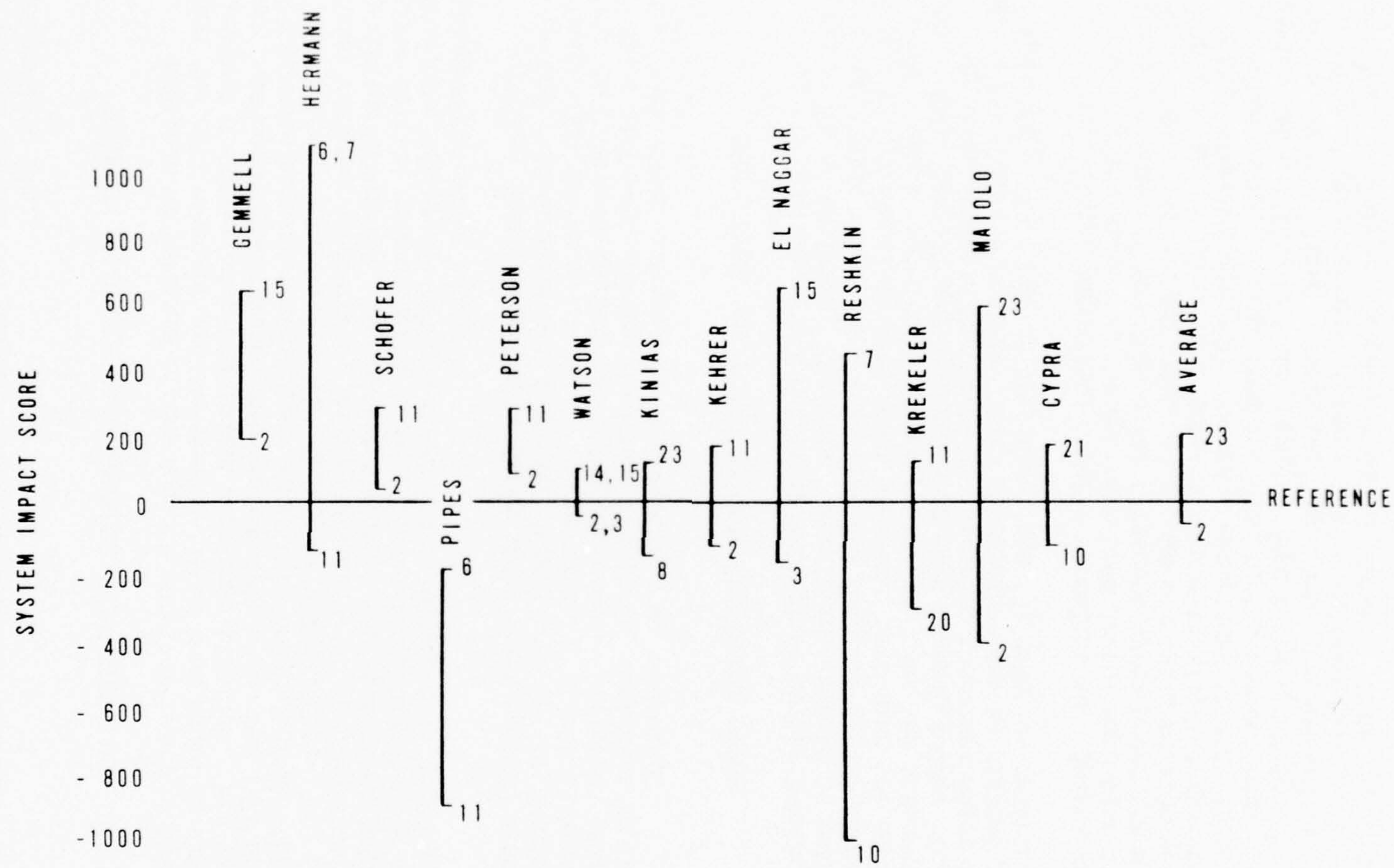

FIGURE EB-1

RANGE OF VARIATION AMONG INDIVIDUAL JUDGES

(HIGH AND LOW SYSTEM SCORES)

regarding which system is most desirable and which is least desirable. The same information is summarized in Table EB-2 for readers who want to explore the matter differently or make comparisons among judges.

Gemmell: With equal options the order of preference for treatment type from best to worst, respectively, is consistently IV, V, III, II, I. Without exception, all systems have net positive impacts, relative to the reference, and all Type III, IV and V systems are more positive than Type II systems. With respect to sludge management, land reclamation is much preferred over agricultural disposal. The power option creates net positive benefits, and it is more desirable to satisfy all potable needs from Lake Michigan than to recycle system effluent. The preferred system is land treatment with land reclamation, potable needs from Lake Michigan and power synergism. The reference system is least preferred.

Hermann: For equivalent combinations of options, there is a consistent ordering of preference for treatment type, from highest to lowest, respectively. of III, II, V, I, IV. Type III , II and V systems all have net positive impacts. Type IV systems are neutral or negative, with the neutral systems having land reclamation and potable needs from Lake Michigan. Land reclamation is preferred over agricultural sludge disposal, and satisfaction of potable needs from Lake Michigan is preferred over reuse. With Type V systems power is preferred, but with Type IV the opposite is true. The most preferred system is Type III with land reclamation and potable needs from Lake Michigan. The worst is Type IV with agricultural sludge, potable reuse, and power synergism.

Schofer: In the absence of power synergism, there is a consistent ordering by treatment type. Type V is best, followed in order by IV, III, II and I. All systems produce net positive impacts relative to the reference. When power is added, IV and V switch places, with land treatment becoming more desirable. Power is much preferred over no power, agricultural sludge disposal is preferred over land reclamation, and reuse of effluent is preferred over satisfaction of all potable needs from Lake Michigan. The most desirable system is land treatment (IV), with agricultural sludge disposal, potable reuse and power synergism. The least desirable is the reference (I).

Pipes: The best system is the reference (I). All others produce net negative impacts. There is a consistent ordering of treatment types, with I preferred over III preferred over V preferred over II preferred over IV. Land reclamation is more desirable than agricultural sludge disposal. Power produces negative impacts and satisfaction of potable needs from Lake Michigan is much preferred over potable reuse. The least desirable system is land treatment with agricultural sludge disposal, potable reuse and power. Pipes and Schofer are almost complete opposites.

Peterson: All systems produce net positive impacts relative to the reference. In the absence of power synergism, treatment types are ordered consistently V, III, IV, II, I, from most to least desirable, respectively. When power is added, land treatment (IV) becomes more desirable than mixed

TABLE EB-2

SUMMARY OF THE INDIVIDUAL POINT OF VIEW

	TREATMENT								SLUDGE	POWER	POTABLE	5 BEST	5 WORST
	NO POWER				POWER								
	A-LM	A-R	L-LM	L-R	A-LM	A-R	L-LM	L-R					
GEMMELL	IV	IV	IV	IV	IV	IV	IV	IV	L	P	LM	IV LLMP	V AR
	V	V	V	V	V	V	V	V	1	NP	R	IV LRP	III AR
	III	III	III	III					A			IV LLM	II ALM
	II	II										IV LR	II AR
	I									IV V		V LLMP	I (ALM)
HERMANN	III	III	III	III					L	NP P	LM	III LLM	IV LRP
	II	II							A	P NP	R	III LR	IV ALMNP
	V	V	V	V	V	V	V	V				IIIALM	IV ALMP
	I											IIIAR	IV ARNP
	IV	IV	IV	IV	IV	IV	IV	IV				II ALM	IV ARP
SCHOFER	V	V	V	V	IV	IV	IV	IV	A	P	R	IV ARP	IV LLMNP
	IV	IV	IV	IV	V	V	V	V	L	1	LM	IV LRP	IIILLM
	III	III	III	III						NP		IV ALMP	II AR
	II	II										IV LLMP	II ALM
	I											V ARP	I (ALM)
PIPES	I								L	NP	LM	III LLM	IV ALMP
	III	III	III	III					A	P	1	III ALM	II AR
	V	V	V	V	V	V	V	V			R	III LR	IV ARNP
	II	II										III AR	IV LRP
	IV	IV	IV	IV	IV	IV	IV	IV				V LLMNP	IV ARP
PETERSON	V	V	V	V	IV	IV	IV	IV	L	P	R	IV ARP	IV ALM
	III	III	III	III	V	V	V	V	A	1	LM	IV LLMP	II AR
	IV	IV	IV	IV						NP		IV ALMP	II ALM
	II	II										V LRP	I ALM
	I												
WATSON	III	III	III	III					L	P	R=LM	IV LP	III A
	IV	IV	IV	IV	IV	IV	IV	IV	A	NP		V LP	IV A
	V	V	V	V	V	V	V	V				IV AP	V A
	I											III L	I
	II	II										IV L	II
KINIAS	II	II	III	III	V	V	V	V	L	P	R	VLRP	V ALMP
	I	V	V	V	IV	IV	IV	IV	1	NP	LM	III LRNP	IV AR
	V	III	IV	IV					A			II ARNP	V ALMNP
	III	IV								IV:		V LRNP	III ALMNP
	IV									P=NP		V LLMP	IV ALM
KEHRER	III	III	IV	V	IV	IV	IV	IV	A	IV V P NP	R	IV ARP	II AR
	I	V	V	IV	V	V	V	V	L	NP P	1	IV LRP	V ALMP
	V	IV	III	III							LM	V LRNP	IV LLM
	IV									V:I> A		III ARNP	III LLM
	II	II										V ARNP	II ALM
EL-NAGGER	IV	IV	IV	IV	IV	IV	IV	IV	L	IV V P NP	LM	IV LLMP	V ARNP
	III	III	V	V	V	V	V	V	1	NP P	R	IV LRP	V ALMP
	V	V	III	III					A			IV LLMNP	V ARP
	I											IV LRNP	II ALM
	II	II										IV ALMP	II AR
RESHKIN	I				V	V	V	V	L	NP	R	III LR	IV LLMP
	III	III	III	III	IV	IV	IV	IV	1	P	LM	III LLM	IV ARNP
	V	V	V	V					A			V LRNP	IV ALMNP
	II	II										V LLMNO	IV ARP
	IV	IV	IV	IV								V LRP	IV ALMP
KREKELER	I				IV	IV	IV	IV	A	P	R	IV ARP	II ALM
	IV	IV	IV	IV	V	V	V	V	L	NP	1	IV LRP	III ALM
	II	II									LM	IV ALMP	III LLM
	III	III	III	III								IV LLMP	V ALM
	V	V	V	V								I (ALM)	V LLM
MAIOLO	V	V	IV	IV	V	V	V	V	L	P	R	V LRP	I (ALM)
	IV	IV	V	V	IV	IV	IV	IV	A	NP	LM	V ARP	III AR
	I		III	III						(V)		V LLMP	III ALM
	III	III								IV:		IV LR	II AR
	II	II								P=NP		V ALMP	II ALM
CYPRA	V	V	V	V	V	V	V	V	L	NP	R	V LRMP	IV ALMNP
	I				IV	IV	IV	IV	A	P	LM	V LLMNP	II AR
	III	III	III	III								V LRP	II ALM
	IV	IV	IV	IV								V LLMP	IV ARP
	II	II										III LR	IV ALMP

*Increasing preference bottom to top

treatment V. Land reclamation is preferred over agricultural sludge disposal. Potable reuse is preferred over supplying potable needs from Lake Michigan, and power is much preferred over no power. The most desirable system is land treatment with land reclamation, potable reuse and power.

Watson: All systems except the physical-chemical types produce positive benefits relative to the reference. Treatment types are ordered consistently III, IV, V, I and II, from most to least desirable, respectively. Land reclamation is preferred over agricultural sludge disposal and power is preferred over no power. There is indifference between the two options for potable needs. The most desirable system is land treatment with land reclamation and power. The least desirable system is physical-chemical treatment which has a net negative impact.

Kinias: With no power and land reclamation, treatment Type III is preferred over type V, which is in turn preferred over Type IV. Other options being equal, Type IV is consistently the least desirable treatment process. With agricultural sludge disposal and use of Lake Michigan water for all potable needs, the order is II, I, V, III and IV, respectively, from best to worst. With potable reuse of effluent, the same order persists, except that the reference type is not comparable. With power synergism, Type V is consistently preferred over Type IV. Regarding the other options, land reclamation is much preferred over agricultural sludge disposal, potable reuse is preferred over Lake Michigan, and power is preferred over no power, except in combination with land treatment (IV) where there is indifference between power options. The most preferred system is treatment Type V in combination with land reclamation, potable reuse and power synergism. The least desirable system is land treatment with agricultural sludge disposal and potable needs from Lake Michigan.

Kehrer: With no power and agricultural sludge disposal the order of preference for treatment type is III, V, IV, and II from best to worst, respectively. Where it is comparable, the reference treatment is second to Type III. With land reclamation, Type III is the least desirable. Type IV dominates when potable needs are supplied from Lake Michigan, while Type V is best with reuse. In the presence of power, Type V is preferred over Type IV. All systems have net positive impacts except all Type II, which are negative, Type III with land reclamation, potable needs from Lake Michigan and no power, Type IV with potable needs from Lake Michigan and no power, and Type V with potable needs from Lake Michigan. For sludge management agricultural disposal is preferred over land reclamation except with treatment Type V, when land reclamation is preferred. Reuse of effluent for potable needs is much preferred over exclusive use of Lake Michigan water. With land treatment (IV) power is preferred, while with Type V, no power is preferred. The most desirable system is land treatment (IV) with agricultural sludge disposal, potable reuse and power. The worst system is physical-chemical treatment with agricultural sludge disposal and potable needs from Lake Michigan.

El-Naggar: When options are equivalent the order of preference for treatment Type is IV, III, V, I and II, respectively, from best to worst with land reclamation V and III change places. All Type III and IV systems have net positive impacts. Type V systems with land reclamation are also positive. All Type II systems are negative in impact. For sludge management, land reclamation is much preferred over agricultural disposal. Exclusive use of Lake Michigan for potable needs is preferred over reuse of effluent. With treatment Type IV power is an enhancement while with Type V it detracts. The most desirable system is treatment Type IV with land reclamation, potable needs from Lake Michigan and power. The least desirable system is Type II with agricultural sludge disposal and reuse.

Reshkin: Other options being equal, the order of preference for treatment Type is I, III, V, II and IV, from highest to lowest respectively. Only Type III and Type V systems, both with land reclamation, have net positive impacts relative to the reference system. All other systems have net negative impacts. The systems with positive impacts are enhanced by land reclamation, which is greatly preferred over agricultural sludge disposal and is not present in the reference system. No power is preferred to power synergism, and reuse is preferred to exclusive use of Lake Michigan for potable needs. The best system is Type III with land reclamation and potable reuse. The worst system is Type IV with agricultural sludge disposal, potable needs from Lake Michigan and power synergism.

Krekeler: With equal options, the preference for treatment Type is I, IV, II, III and V, from highest to lowest, respectively. With power added, Type IV systems have net positive impacts, relative to the reference, but all other systems produce negative impacts, regardless of options. Agricultural sludge disposal is preferred over land reclamation, and power is preferred over no power. With regard to potable needs reuse is much preferred over all needs from Lake Michigan..The best system is Type IV with agricultural sludge disposal, reuse and power. The worst system is Type V with land reclamation and potable needs from Lake Michigan.

Maiolo: With equivalent options, the order of preference for treatment Type is V, IV, I, III and II, from best to worst, respectively. All Type IV and V systems have net positive impacts, relative to the reference system. Type III systems with land reclamation are also positive, and all other systems are negative. With agricultural sludge disposal, Type V treatment is preferred over Type IV, but with land reclamation the order is reversed. With power, V is preferred over IV. For disposal of sludge, land reclamation is preferred over agriculture. Reuse is favored over Lake Michigan for potable needs. With Type V systems, power is preferred, but with Type IV systems there is no preference between power and no power. The most preferred system is Type V with land reclamation, potable reuse and power. The least preferred system is Type II with agricultural sludge disposal, and potable needs from Lake Michigan.

Cypra: With equivalent options, preference for treatment Type is from V at the top through I, III, IV and II, respectively. All Type V systems

have net positive impacts. Also positive are Type III systems with land reclamation and Type IV systems with land reclamation and no power. With power, System V is preferred over IV. For sludge disposal, land reclamation is preferred over agriculture. No power is better than power, and reuse is preferred to supplying all potable needs from Lake Michigan. The best system is Type V with land reclamation, reuse and no power. The worst system is Type IV with agricultural sludge disposal, potable needs from Lake Michigan and power synergism.

INDEPENDENT DIMENSIONS OF VIEWPOINT

Principal components analysis of the thirteen sets of system scores in Table EB-1 indicates that seven independent dimensions of viewpoint are being expressed by the thirteen judges. The first two principal components explain 67.5% of the total inter-judge variation, but explain less than that amount of the information in the scores of the following judges: Pipes (61%), Hermann (53%), Kinias (44%), Kehrer (43%), El-Naggar (57%), and Krekeler (50%). The other judges are relatively better explained by these two dimensions: Reshkin (98%), Maiolo (72%), Cypra (75%), Gemmell (72%), Schofer (86%), Peterson (76%), and Watson (91%). In order to lose no more than 3% for any one judge, seven dimensions are required, and other criteria suggest that seven is the simplest adequate explanation. These seven factors explain 98.8% of the total inter-judge variation in system scores.

Table EB-3 gives the average system scores (in standard deviations from the reference system) for the first two principal components. Table EB-4 shows how each judge correlates with each of these dimensions of judgment. Table EB-5 gives the average system scores (again in standard deviations from the reference) for seven independent dimensions of judgment (varimax rotation of first seven principal components). Table EB-6 shows how each judge is correlated with these seven independent viewpoints.

The information in Table EB-6 is quite complex. It can be simplified by associating each factor with the judges who have half or more of their variation explained by it. Thus, Factor 1 is the El-Naggar, Gemmell, Watson point of view. Factor 2 is closest to Krekeler. Factor 3 is primarily Kinias, Reshkin, and Cypra. Factor 4 is Hermann and anti-Maiolo. Factor 5 explains Peterson and Schofer. Factor 6 is most closely associated with Kehrer, and Factor 7 is dominated by Pipes.

THE UNBIASED PANEL ESTIMATE

From Table EB-6 it is clear that the seven independent viewpoints are not represented equally in the panel. They range from 20.1% (Factor 5) of the total variation explained down to a low of 7.7%(Factor 6). Thus, factor 5 is represented 2.74 times as strongly as Factor 6. If it is

TABLE EB-3

TWO PRINCIPAL DIMENSIONS OF VIEWPOINT
(62.5% of total inter-judge variation)

SYSTEM NUMBER	PRINCIPAL DIMENSION(P_1)	SECONDARY DIMENSION(P_2)
1	0.000	0.000
2	-0.603	-0.548
3	-0.203	-0.526
4	0.749	0.657
5	1.135	0.705
6	1.098	2.018
7	1.336	2.412
8	1.151	-0.750
9	1.553	-0.728
10	2.356	-1.021
11	2.758	-0.997
12	2.068	0.750
13	1.667	0.728
14	3.273	0.481
15	2.871	0.459
16	1.264	0.218
17	1.667	0.241
18	1.941	0.156
19	2.343	0.180
20	1.758	1.688
21	2.160	1.712
22	2.435	1.627
23	2.836	1.650

Scores are in standard deviations from reference.

TABLE EB-4

CORRELATION OF INDIVIDUAL JUDGES WITH TWO PRINCIPAL DIMENSIONS OF JUDGMENT

JUDGE	PRIMARY DIMENSION	SECONDARY DIMENSION	PERCENT OF JUDGE EXPLAINED
Gemmell(10)	$\boxed{.844}$	.093	72
Hermann(11)	-.501	.526	53
Schofer(12)	$\boxed{.925}$	-.059	86
Pipes(13)	-.459	.632	61
Peterson(14)	$\boxed{.865}$	-.124	76
Watson(16)	$\boxed{.884}$	.360	91
Kinias(31)	-.046	.663	44
Kehrer(32)	.654	-.004	43
El-Naggar(33)	$\boxed{.721}$	.219	57
Reshkin(34)	-.214	$\boxed{.966}$	98
Krekeler(35)	.571	-.415	50
Maiolo(36)	$\boxed{.830}$	.175	72
Cypra(38)	.102	$\boxed{.859}$	75
Average*	.468	.865	95
Percent of total Inter-Judge variation explained:	42.9%	24.6%	67.5%

*"Average" is the vector scores calculated from the row sums of the average C-matrix. The equation relating "Average" to the scores in Table EB-2 is

$$\text{Average} = 3.78 + 31.15\, P_1 + 62.58\, P_2$$

with $R^2 = 0.946$.

TABLE EB-5

SYSTEM SCORES FROM 7 INDEPENDENT POINTS OF VIEW (VARIMAX ROTATION OF 7 PRINCIPAL COMPONENTS)

FACTOR		I		II		III		IV		V		VI		VII
% judges		19.7		10.6		18.7		11.7		20.1		19.7		10.2
% avg.		16.1		2.9		44.1		0.6		23.3		1.2		11.6
SYSTEM	RANK	SCORE	RANK	SCORE	RANK	SCORE	RANK	SCORE	RANK	SCORE	RANK	SCORE	RANK	SCORE
1	22	0.000	1	0.000	12	0.000	23	0.000	23	0.000	15	0.000	1	0.000
2	20	0.177	4	-1.450	13	-0.004	5	3.190	21	1.002	23	-1.700	22	-3.688
3	23	-0.152	4	-0.792	5	0.863	3	3.226	22	0.759	18	-0.210	23	-4.220
4	14	1.206	19	-2.895	21	-1.036	2	3.390	9	2.776	10	0.536	3	-0.860
5	16	0.876	15	-2.253	14	-0.166	1	3.532	13	2.567	1	2.036	5	-1.396
6	5	2.240	18	-2.655	7	0.751	4	3.214	12	2.585	19	-0.378	4	-1.143
7	8	1.907	10	-1.463	4	1.183	6	2.883	15	2.306	7	1.048	2	0.367
8	13	1.419	17	-2.480	22	01.690	14	1.153	17	1.851	16	-0.034	15	-2.224
9	15	1.088	12	-1.820	19	-0.824	13	1.189	18	1.606	5	1.456	11	-2.757
10	9	1.818	6	-1.114	23	-1.735	8	2.202	5	3.193	13	0.320	11	-1.899
11	12	1.488	3	-0.454	20	-0.868	7	2.238	6	2.949	2	1.811	7	-2.432
12	4	2.505	11	-1.711	8	0.702	21	0.941	20	1.287	8	0.995	27	-2.598
13	3	2.835	16	-2.370	14	-0.166	22	0.904	19	1.531	20	-0.495	13	-2.060
14	2	2.905	2	-0.345	10	0.660	9	1.990	10	2.628	6	1.349	16	-2.274
15	1	3.235	5	-1.005	17	-0.208	10	1.954	7	2.873	17	-0.141	8	-1.741
16	17	0.584	22	-3.593	18	-0.695	17	1.116	8	2.870	14	0.259	11	-1.980
17	19	0.254	20	-2.934	11	0.172	17	1.152	11	2.627	4	1.749	19	-2.513
18	18	0.411	13	-1.987	16	-0.191	20	1.100	1	4.065	22	-1.014	7	-1.552
19	21	0.082	7	-1.318	9	0.675	18	1.137	2	3.821	11	0.475	14	-2.085
20	6	2.107	23	-3.606	6	0.758	15	1.170	14	2.347	12	0.383	10	-1.927
21	10	1.778	21	-2.947	2	1.625	11	1.206	16	2.102	3	1.872	18	-2.459
22	7	1.935	14	-1.991	3	1.260	16	1.155	3	3.542	21	-0.891	6	-1.498
23	11	1.604	8	-1.331	1	2.128	12	1.191	4	3.296	9	0.599	12	-2.031

Scores are measured in units of standard deviations from the reference within each factor.

TABLE EB-6

CORRELATION OF INDIVIDUAL JUDGES WITH THE SEVEN INDEPENDENT POINTS OF VIEW

JUDGE	FACTOR 1	2	3	4	5	6	7	% JUDGE EXPLAINED
Gemmell(10)	$\boxed{.859}$	.043	.045	-.147	.376	.007	-.268	97.7
Hermann(11)	-.131	-.214	.261	$\boxed{.827}$	-.023	-.120	.376	97.2
Schofer(12)	.375	.088	-.110	-.177	$\boxed{.857}$	.224	-.139	99.6
Pipes(13)	-.052	-.124	.255	.285	-.233	-.055	$\boxed{.869}$	97.6
Peterson(14)	.247	.197	-.086	-.070	$\boxed{.880}$	.214	-.225	98.3
Watson(16)	$\boxed{.705}$	.138	.217	-.149	.619	.078	.134	99.3
Kinias(31)	-.009	.197	$\boxed{.953}$	.122	-.143	.056	-.076	99.1
Kehrer(32)	.143	.228	.085	-.166	.346	$\boxed{.877}$	-.051	99.9
El-Naggar(33)	$\boxed{.965}$	.049	.007	-.109	.149	.131	.072	99.0
Reshkin(34)	.038	-.325	$\boxed{.823}$	.130	-.096	-.044	.426	99.3
Krekeler(35)	.133	$\boxed{.884}$	-.155	-.196	.258	.253	-.116	99.4
Maiolo(36)	.357	-.031	.209	$\boxed{-.702}$	.525	.173	-.047	97.1
Cypra(38)	.058	-.515	$\boxed{.757}$	0.284	.138	.041	.235	99.8
Average	.401	-.169	.664	.075	.483	.108	.340	99.7
% of Total Variation Explained	19.7	10.6	18.7	11.7	20.1	7.7	10.2	98.7
% of Avg. Factor Explained	16.1	2.9	44.1	0.6	23.3	1.2	11.6	99.7

A box around the correlation means that the judge has at least half of his inter-system variation explained by that factor.

assumed that all possible viewpoints are represented, albeit unequally, we can estimate how an unbiased panel would rate the systems. This can be done by averaging the seven scores in Table EB-5 for each system. The resulting "unbiased" panel scores are shown in Table EB-7. The effect of this"unbiasing" operation is generally a relative increase in the scores for systems with potable reuse and agricultural sludge disposal. There is also a tendency for the AB + Land system scores (16 through 23) to drop. The Land systems with land reclamation also drop while the Land systems with agricultural sludge disposal tend to improve. (Note: These unbiased scores cannot be compared rigorously with the "average" scores presented earlier in the report. The "average" scores were computed from the product of the average A and B matrices while the unbiased scores were computed by averaging individual C matrices. The generalizations about the effect of "unbiasing" were taken from a comparison of "Panel-biased" average scores computed by averaging individual C matrices. (See Figure EB-2 for this comparison.)

In the unbiased estimate the "best" system is #7, AB treatment with land reclamation and potable reuse. The best three systems are 7 (Type III), 14 (Type IV), and 23 (Type V), all with land reclamation and potable reuse. In addition, 14 and 23 include the power option. The fourth-best system is #5, AB treatment with agricultural sludge disposal and potable reuse. Clearly, PC treatment is dominated in the unbiased panel as well as in the actual panel.

SYSTEM SCORES IN REDUCED JUDGMENT SPACE

The independent points of view expressed in Tables EB-1, 2, 3, and 5 are difficult to interpret because of their numerical complexity. The two-dimensional system in Table EB-3 is expressed graphically in Figure EB-3. Here the two principal components are the axes, and the system scores are plotted in these two dimensions of judgment. The diagonal lines describe the relationship between the two factors and the system scores computed from average A x average B (average score = $31.15F_1 + 62.58F_2$). This scoring function explains 94.6% of the average scores but only 67.5% of the inter-judge variation. This shows that considerable information is missing in the average scores that is contained in the individual judge scores.

From the point of view of Factor 1, system 14 (Type IV) is clearly the best while 7 (Type III) is best from the point of view of Factor 2. From a combined point of view systems 6, 7, 20, 21, 22, and 23 form a dominant group. Systems 14 and 15 gain importance as the emphasis on Factor 1 is increased. (This can be visualized by rotating the diagonal lines clockwise.) Examination of Table EB-3 reveals that Factor 1 can be interpreted as a composite of the judgments made by Schofer, Watson, Peterson, Gemmell, Maiolo, and El Naggar with contributions from Kehrer, Krekeler, (anti-) Hermann and (anti-) Pipes. Factor 2 can be interpreted as a composite of the judgments made by Reshkin and Cypra with contributions from Kinias, Pipes, Hermann, and (anti-) Krekeler.

TABLE EB-7

UNBIASED PANEL ESTIMATE OF SYSTEM SCORES
SUMMED ACROSS 7 UNIT WEIGHTED FACTORS

ALTERNATIVE	SYSTEM	SCORE	RANK	RANKING WITHIN CATEGORY avg.	high	low
I	1	0.000	18	18	18	18
II	2	- 2.473	23	21.5	20	23
	3	- 0.526	20			
III	4	3.117	10	5.5	1	10
	5	5.196	4			
	6	4.614	7			
	7	8.231	1			
IV	8	- 2.005	22	12	2	22
	9	- 0.062	19			
	10	2.785	12			
	11	4.732	6			
	12	2.121	13			
	13	0.179	17			
	14	6.913	2			
	15	4.967	5			
V	16	- 1.439	21	12.1	3	21
	17	0.507	16			
	18	0.841	15			
	19	2.787	11			
	20	1.232	14			
	21	3.177	9			
	22	3.512	8			
	23	5.456	3			

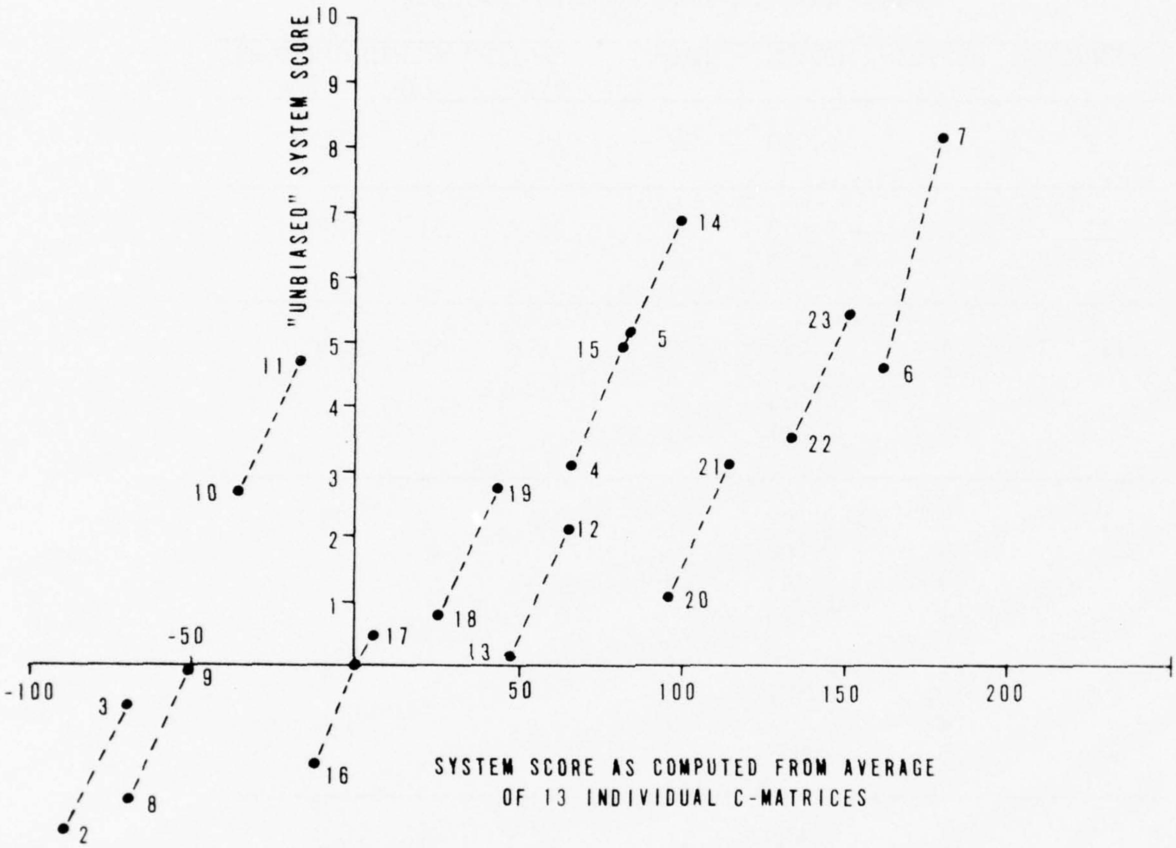

FIGURE EB-2

COMPARISON BETWEEN "UNBIASED" AND "BIASED" SYSTEM SCORES

Systems connected by a dashed line differ only with respect to the potable needs option. In all cases "reuse" is preferred over "L.M." and unbiasing the scores enhances reuse.

(The "biased" system scores used in the comparison were computed from the average of individual C-Matrices, rather than from the C Matrix that is the product of the average A and B Matrices. This is necessary, because the "unbiased" scores were derived from individual C Matrices. The C Matrices and resulting scores computed by the two different approaches differ slightly.)

Thus, the benefit of Figure EB-3 is to break the average scores into two dimensions, each of which can be associated with different sets of judges with rather different points of view. If there is any reason to place more credability on one set than the other, the scores can be modified through a rotation of the scoring function.

The notion of breaking the judgments into the seven independent components is even more appealing, because it preserves aspects of individual points of view that are masked in the averaging process. This information is recovered principally in Factors 2 and 4 of Tables EB-5 and 6. Unfortunately we cannot draw a seven-dimensional graph as easily as one with only two or three dimensions. We can, however, draw a map of the hierarchies of similarity and difference among systems in the "unbiased" seven dimensions of judgment expressed in Table EB-5. This map is shown in Figure EB-4. The map is in the form of a dendragram or taxonomic tree. The systems whose scores are closest together in the seven dimensional space are linked at the top of the tree, with the descending trunks showing increasing distances among the groups. The vertical axis at the left is the percent of the total intersystem variation that is contained within the groups that have been formed above that level. Thus at the 7-group level, only 31.2% of the difference in scores is within groups while more than twice as much (68.8%) is still between groups. Loosely defined, there are at this level seven rather different types of "system." These types and their average group score are as follows:

TABLE EB-8

GROUP	SYSTEMS	ALTERNATIVE	unbiased AVERAGE GROUP SCORE
1	4,5,6,7	Type III	5.29
2	10,11,14,15	Type IV with power	4.85
3	18,19,22,23	Type V with power	3.15
4	12,13,20,21	Type IV & V: land, no power	1.68
5	1	Reference	0.00
6	8,9,16,17	Type IV & V: ag., no power	- 0.80
7	2,3	Type II	- 1.50

The groupings and group scores may change if the decision is made to weight the seven factors unequally. For example, if we want to examine impacts from a specialized point of view or if credability differences are thought to exist among judges, the seven dimensions can be weighted accordingly and the system scores and/or proximity groupings computed.

Figure EB-4 also gives a good reading of the extent to which system variations contribute to impact differences. The variable least responsible for system differences is the potable water supply option. In all cases where the option is applicable, each system is most similar in impact to the

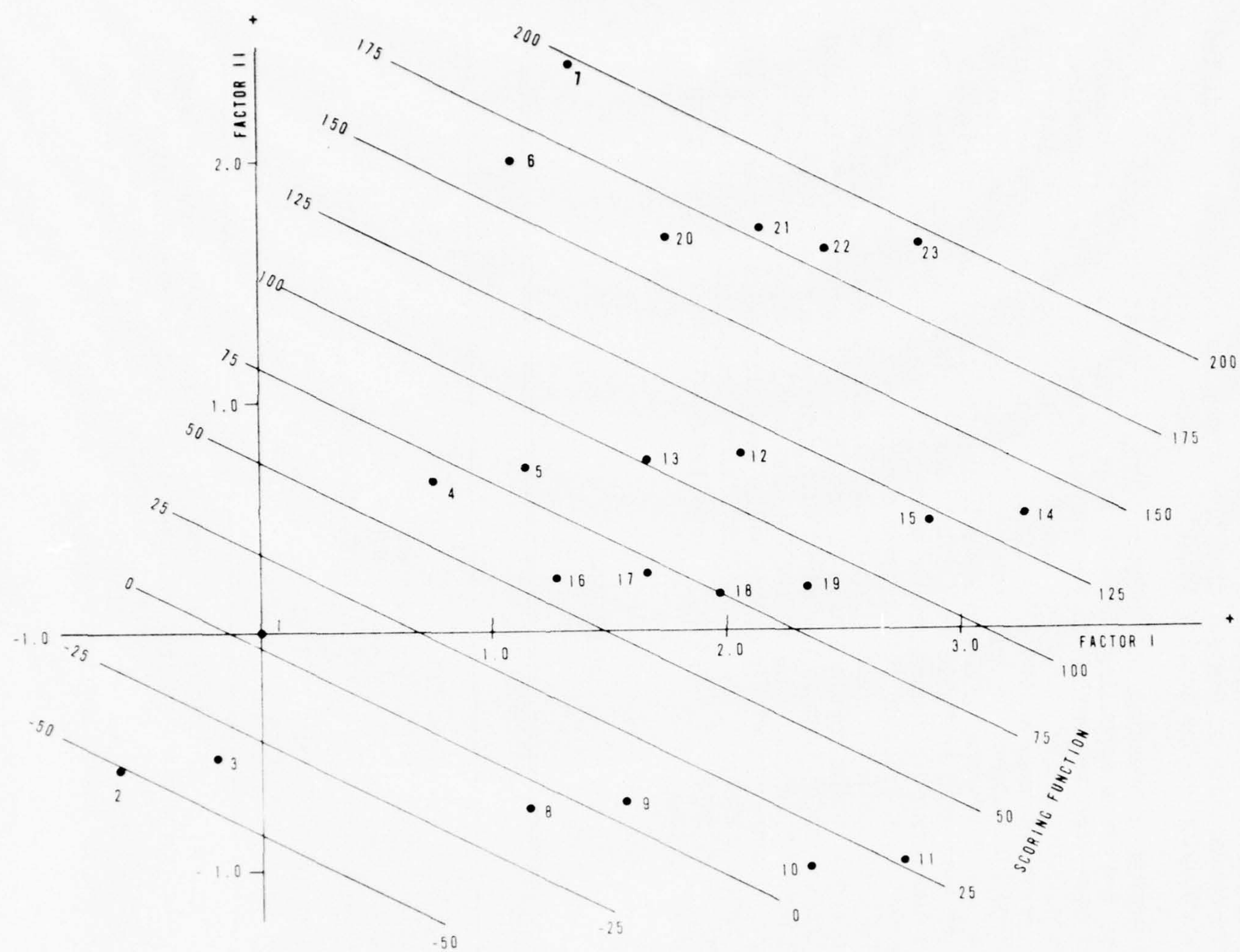

FIGURE EB-3

TWO DIMENSIONAL DISPLAY OF SYSTEM SCORES

FIRST 2 PRINCIPAL COMPONENTS OF INTER-JUDGE VARIATION

94.6% OF MEAN SCORE VECTOR
67.5% OF INTER-JUDGE VARIATION

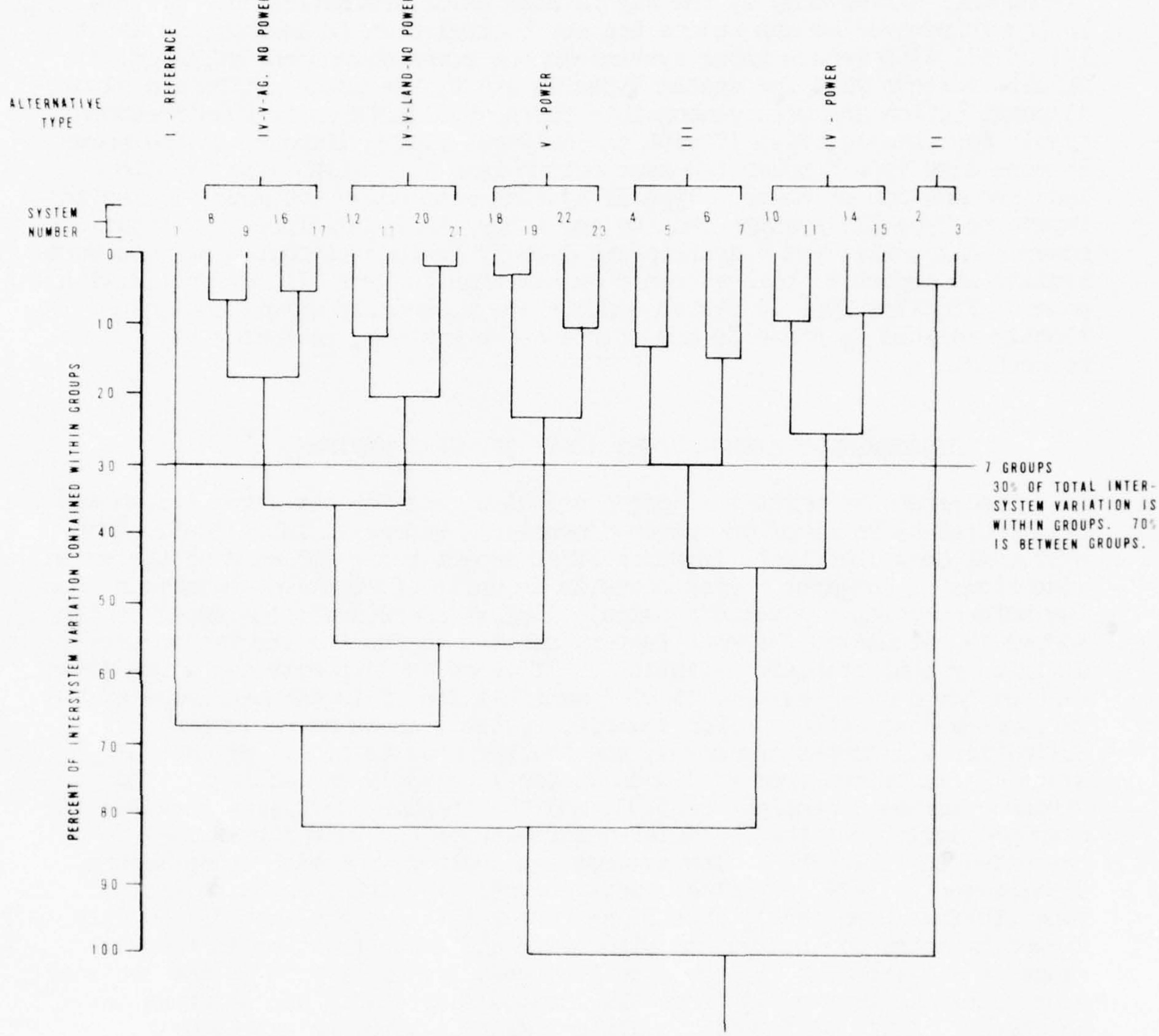

FIGURE EB-4

MAP OF PROXIMITIES (SIMILARITIES) AMONG SYSTEM IN SEVEN DIMENSIONS OF JUDGEMENT

system that varies only by the way potable needs are satisfied. If this option is removed we can reduce the set to twelve while losing only about 15% of all differences among systems in the seven dimensions of judgment. We also observe that for system Types IV and V, the power option and sludge disposal option are more responsible for system differences than treatment type. For example, Type IV with agricultural sludge disposal and no power is more like Type V under the same option than it is like Type IV with land reclamation or power. Type IV systems with power are more similar in impact to Type III systems than to any other, including Type IV without power. Also, all Type V systems and Type IV systems without power are more similar in impact to the reference system than to Type III or Type IV with power. Finally, Type II system impacts are apparently unique and not closely related to those of any of the other systems, including the reference.

DISAGREEMENT AMONG JUDGES ABOUT SPECIFIC SYSTEMS

The extent to which the judges are disparate for any given system can be measured by means of the seven-dimensional scores in Table EB-5. Each system is described there in terms of an impact score for each of the seven dimensions of judgment. Each score is in units of standard deviations from the reference for a given dimension. (The standard deviation among system scores is calculated for each factor, and the scores for the factor are divided by that standard deviation.) If there is disparity among the seven factors for a given system, it will manifest itself in the magnitude of the variance across factors. For example, system 1 shows no variation (by definition all scores are zero), and the variance is zero. By contrast, system 3 fluctuates from -4.220 on Factor 7 to +3.19 on Factor 5. The variance across dimensions is 5.03, and the standard deviation is 2.24. Standard deviations thus calculated for each of the 23 systems are presented in Table EB-9. The systems are ordered from highest to least disagreement. Only four clear facts emerge: 1) with regard to system type (treatment process), Type II systems (2&3) have the most disparately viewed impacts, 2) the systems with power all group together in the mid-range of disagreement, 3) the most desirable system overall in the unbiased panel estimate (system 7) shows the least disagreement, and 4) there is relatively little difference in disagreement between the extremes.

DESCRIPTION OF SPECIFIC IMPACTS FROM THE VIEWPOINT OF INDIVIDUAL JUDGES

The discussion of individual viewpoints thus far has been restricted to analysis of overall system scores. For maximum usefulness, the individual viewpoints should be examined in terms of specific impacts of system elements on environmental parameters (A matrix) and environmental parameters on human activities (B matrix). To generate independent A,B, and C matrices corresponding to the independent dimensions identified above is

TABLE EB-9

DISAGREEMENT AMONG JUDGES

VARIANCE RANK	SYSTEM NUMBER	STANDARD DEVIATION	SYSTEM ELEMENTS ALTERNATIVE	SLUDGE	POTABLE	POWER
1	3	2.24	II	A	R	
2	4	2.23	III	A	LM	
3	2	2.20	II	A	LM	
4	16	2.18	V	A	LM	
5	20	2.18	V	L	LM	
6	21	2.18	V	L	R	
7	6	2.16	III	L	LM	
8	5	2.14	III	L	R	
9	17	2.09	V	A	R	
10	10	2.05	IV	A	LM	X
11	18	2.05	V	A	LM	X
12	22	2.02	V	L	LM	X
13	15	1.96	IV	L	LM	X
14	11	1.95	IV	A	R	X
15	19	1.90	V	A	R	X
16	13	1.89	IV	L	LM	
17	23	1.89	V	L	R	X
18	8	1.83	IV	A	LM	
19	14	1.83	IV	L	R	X
20	12	1.80	IV	L	R	
21	9	1.77	IV	A	R	
22	7	1.44	III	L	R	
23	1	0	I	A	LM	

$$F_{range} = \frac{(2.24)^2}{(1.44)^2} = \frac{5.03}{2.06} = 2.44 \qquad v_1 = 6,\ v_2 = 6$$

$$\frac{(5.03)}{(1.77)^2} = \frac{5.03}{3.15} = 1.60 \qquad v_1 = 6,\ v_2 = 6$$

mathematically possible but not feasible at this time. Rather, we present below a simplified A matrix for each of the thirteen judges. An approximate idea of the A matrix best representing a given dimension of judgment can be obtained by examining the A matrix for the judge or judges associated with that dimension (see Table EB-4 and 6).

The A matrices presented below have been simplified so that they display only strongly positive or strongly negative impacts. Anything greater than or equal to +2 is indicated as (+) while everything less than or equal to -2 appears as (-). Everything else has been left blank. The purpose is to display only the strongly positive or negative judgments so that the reader can get an approximate idea about the major differences among judges regarding specific A matrix impacts.

EXPLANATION OF SPECIFIC IMPACTS

The designer and decision maker need to know what impacts will result from their alternative systems. We have tried to present a complete statement of the panelists' judgments in this regard, first in an aggregate way, and, second from disparate points of view. More useful, however, would be an explanation of why it is believed that the reported impacts will occur, i.e., what are the specific processes by which each system element produces it reported impacts.

In general no one person is capable of explaining the aggregate view, because it is a multidisciplinary phenomenon, and no one is able to encompass all facets. We do have, however, the verbalized comments of the judges as stimulated by their efforts to make A-matrix and B-matrix judgments.

TABLE EB- 10

INDIVIDUAL A MATRIX

GEMMELL: WATER RESOURCES ENGINEER-PLANNER

(Correlates with Factor 1)

PRIMARY IMPACT DIMENSION

SYSTEM ELEMENT	Surface Water Quality 1	Surface Water Quantity 2	Ground Water Quality 3	Ground Water Quantity 4	Air Quality 5	Sensory Quality 6	Residential Land Use 7	Commercial & Industrial LU 8	Agricultural Land Use 9	Recreation & Open Space 10	Soil Quality 11	Mineral Resources 12	Energy 13	Access 14	Biotic Communities 15	Unique or Rare Things 16
1 64 Plant																
2 33 Plant	+	+				+				+						
3 17 Plant	+	+				+				+						
4 Land	+	+				+				+						
5 5 Plant + Land		+				+	+		-	+			-			
6 64 Plant CB																
7 33 Plant PC					-	-						-	-		-	
8 17 Plant AB													-			
9 Land	+	+	-	-				+	-	+				-	+	
10 5 Plant + Land									-	+			-	-		
11 Ag/CB																
12 Ag/PC									+	+						
13 Ag/AB									+	+						
14 Ag/Land									+	+						
15 Ag/AB + Land									+	+						
16 Land Reclaim						+	+			+	+	+			+	
17 Nav-Rec/64																
18 Nav-Rec/33	+	+				+	+			+						
19 Nav-Rec 17	+	+				+	+			+						
20 Nav-Rec/Land	+	+				+	+			+			-			
21 Nav-Rec/AB+L	+	+				+	+			+						
22 All from L.M.																
23 Reuse																
24 Power/6-4																
25 Power/Land						+	+	+	+							
26 Power/AB+L							+									

TABLE EB- 11

INDIVIDUAL A MATRIX

HERMANN: ENVIRONMENTAL HEALTH ENGINEER

(Correlates with Factor 4)

PRIMARY IMPACT DIMENSION

SYSTEM ELEMENT	Surface Water Quality 1	Surface Water Quantity 2	Ground Water Quality 3	Ground Water Quantity 4	Air Quality 5	Sensory Quality 6	Residential Land Use 7	Commercial & Industrial LU 8	Agricultural Land Use 9	Recreation & Open Space 10	Soil Quality 11	Mineral Resources 12	Energy 13	Access 14	Biotic Communities 15	Unique or Rare Things 16
1 64 Plant																
2 33 Plant																
3 17 Plant	+	+			+	+	+	+	+	+	+		+	+		
4 Land						+			+	+	+					
5 5 Plant + Land					+	+			+	+	+					
6 64 Plant CB																
7 33 Plant PC																
8 17 Plant AB	+		+		+	+										
9 Land					+	+	-	-	+	+				-		-
10 5 Plant + Land				+	+	+	-	-	+	+				-		-
11 Ag/CB																
12 Ag/PC									-							
13 Ag/AB																
14 Ag/Land					+	+			+	+						
15 Ag/AB + Land					+	+			+							
16 Land Reclaim													-			
17 Nav -Rec/64																
18 Nav-Rec/33																
19 Nav Rec 17	+	+											+			
20 Nav -Rec/Land		-							+					-		
21 Nav -Rec/AB+L							-	-	+	+				-		-
22 All from L.M.																
23 Reuse																
24 Power/6-4																
25 Power/Land							-									
26 Power/AB+L								+	+							

INDIVIDUAL A MATRIX

SCHOFER: URBAN SYSTEMS ENGINEER

(Correlates with Factor 5)

PRIMARY IMPACT DIMENSION

SYSTEM ELEMENT	Surface Water Quality 1	Surface Water Quantity 2	Ground Water Quality 3	Ground Water Quantity 4	Air Quality 5	Sensory Quality 6	Residential Land Use 7	Commercial & Industrial LU 8	Agricultural Land Use 9	Recreation & Open Space 10	Soil Quality 11	Mineral Resources 12	Energy 13	Access 14	Biotic Communities 15	Unique or Rare Things 16
1 64 Plant																
2 33 Plant		+				+	+		–	+						
3 17 Plant						+	+		–	+			–			
4 Land		+				+	+		–	+			–			
5 5 Plant + Land	+	+				+				+						
6 64 Plant CB																
7 33 Plant PC					–	–	+					–	–			
8 17 Plant AB							–	–					–			
9 Land									–	–			–			
10 5 Plant + Land							–		–				–			
11 Ag/CB																
12 Ag/PC			–						–				–			
13 Ag/AB													+			
14 Ag/Land													+			
15 Ag/AB + Land													+			
16 Land Reclaim						+			+	+	+		–			
17 Nav-Rec/64																
18 Nav -Rec/33	+	+				+				+					+	
19 Nav /Rec 17	+	+				+				+					+	
20 Nav -Rec/Land	+	+				+				+			–		+	
21 Nav -Rec/AB+L																
22 All from L.M.																
23 Reuse																
24 Power/6-4																
25 Power/Land	+					+	+		+							
26 Power/AB+L																

TABLE EB- 13

INDIVIDUAL A MATRIX

PIPES: AQUATIC BIOLOGIST AND CHEMIST

(Correlates with Factor 7)

PRIMARY IMPACT DIMENSION

SYS	M ELEMENT	1 Surface Water Quality	2 Surface Water Quantity	3 Ground Water Quality	4 Ground Water Quantity	5 Air Quality	6 Sensory Quality	7 Residential Land Use	8 Commercial & Industrial LU	9 Agricultural Land Use	10 Recreation & Open Space	11 Soil Quality	12 Mineral Resources	13 Energy	14 Access	15 Biotic Communities	16 Unique or Rare Things
1	+ Plant																
2	33 Plant													-	-		
3	17 Plant					-		-	-	-			-	-	-		
4	Land						-	-	-	-	-	-	-	-	-	-	
5	5 Plant + Land						-	-	-		-	-		-		-	
6	64 Plant CB																
7	33 Plant PC					-	-							-			
8	17 Plant AB	+															
9	Land						-	-	-	-	-			-			
10	5 Plant + Land						-				-			-			
11	Ag/CB																
12	Ag/PC											-	-		-		
13	Ag/AB					+				+	+	+					
14	Ag/Land					+									-		
15	Ag/AB + Land					+									-		
16	Land Reclaim					+				+	+	+					
17	Nav-Rec/64																
18	Nav-Rec/33												-	-			
19	Nav/Rec 17												-	-			
20	Nav-Rec/Land									-			-	-			
21	Nav-Rec/AB+L									-			-	-			
22	All from L.M.																
23	Reuse																
24	Power/6-4																
25	Power/Land																
26	Power/AB+L						-			-	-			+			

TABLE EB- 14

INDIVIDUAL A MATRIX

PETERSON: ENVIRONMENTAL PLANNER

(Correlates with Factor 5)

PRIMARY IMPACT DIMENSION

SYSTEM ELEMENT	Surface Water Quality 1	Surface Water Quantity 2	Ground Water Quality 3	Ground Water Quantity 4	Air Quality 5	Sensory Quality 6	Residential Land Use 7	Commercial & Industrial LU 8	Agricultural Land Use 9	Recreation & Open Space 10	Soil Quality 11	Mineral Resources 12	Energy 13	Access 14	Biotic Communities 15	Unique or Rare Things 16
1 34 Plant																
2 33 Plant		+								+						
3 17 Plant		+								+						
4 Land		+								+						
5 5 Plant + Land		+								+						
6 34 Plant CB																
7 33 Plant PC					-								-			
8 17 Plant AB																
9 Land									+							
10 5 Plant + Land									+				-			
11 Ag/CB																
12 Ag/PC																
13 Ag/AB									+		+					
14 Ag/Land									+		+					
15 Ag/AB + Land									+		+					
16 Land Reclaim																
17 Nav-Rec 64																
18 Nav-Rec/33	+									+						
19 Nav-Rec 17	+												-			
20 Nav-Rec/Land	+												-			
21 Nav-Rec/AB+L	+															
22 All from L.M.																
23 Reuse																
24 Power/5-4																
25 Power/Land	+				+								+			
26 Power/AB+L																

TABLE FB- 17

INDIVIDUAL A MATRIX

KEHRER: ECONOMIST

(Correlates with Factor 6)

PRIMARY IMPACT DIMENSION

SYSTEM ELEMENT	1 Surface Water Quality	2 Surface Water Quantity	3 Ground Water Quality	4 Ground Water Quantity	5 Air Quality	6 Sensory Quality	7 Residential Land Use	8 Commercial & Industrial LU	9 Agricultural Land Use	10 Recreation & Open Space	11 Soil Quality	12 Mineral Resources	13 Energy	14 Access	15 Biotic Communities	16 Unique or Rare Things
1 64 Plant																
2 33 Plant	+	+				+				+						
3 17 Plant	+	+								+			–	–		
4 Land	+	+			–					+		+	–	–	–	–
5 5 Plant + Land	+	+								+			–	–		
6 64 Plant CB																
7 33 Plant PC					–	–	–					–	–			
8 17 Plant AB												+				
9 Land					+	+	+		+	+	+				–	
10 5 Plant + Land					+	+			+	+						
11 AB/CB																
12 AB/PC																
13 AB/AB											+			+		
14 AB/Land						+								+		
15 AB/AB + Land											+	–		+		
16 Land Reclaim						+				+	+		–			
17 Nav-Rec/64																
18 Nav-Rec/33																
19 Nav Rec 17													–	–		
20 Nav-Rec/Land					–		–	–	–	–		–	–	–		
21 Nav-Rec/AB+L													–	–		
22 All from L.M.																
23 Reuse		+				–							+	+		
24 Power/6-4																
25 Power/Land		–				+	+						+	–		
26 Power/AB+L							+									

TABLE EB- 15

INDIVIDUAL A MATRIX

WATSON: REGIONAL ECONOMIST

(Correlates with Factor 1)

PRIMARY IMPACT DIMENSION

SYSTEM ELEMENT	Surface Water Quality 1	Surface Water Quantity 2	Ground Water Quality 3	Ground Water Quantity 4	Air Quality 5	Sensory Quality 6	Residential Land Use 7	Commercial & Industrial LU 8	Agricultural Land Use 9	Recreation & Open Space 10	Soil Quality 11	Mineral Resources 12	Energy 13	Access 14	Biotic Communities 15	Unique or Rare Things 16
1 64 Plant																
2 33 Plant		+														
3 17 Plant		+														
4 Land		+											-			
5 5 Plant + Land		+											-			
6 64 Plant CB																
7 33 Plant PC	+		+		-	-						-	-			
8 17 Plant AB	+		+													
9 Land	+		+						+				-			
10 5 Plant + Land	+		+										-			
11 Ag/CB																
12 Ag/PC													-			
13 Ag/PB									+		+					
14 Ag/Land													-			
15 Ag/AB + Land													-			
16 Land Reclaim										+						
17 Nav -Rec/64																
18 Nav -Rec/33																
19 Nav /Rec 17																
20 Nav -Rec/Land													-			
21 Nav -Rec/AB+L																
22 All from L.M.																
23 Reuse																
24 Power/6-4																
25 Power/Land						+										
26 Power/AB+L																

TABLE EB- 16

INDIVIDUAL A MATRIX

KINIAS: ENVIRONMENTAL ENGINEER

(Correlates with Factor 3)

PRIMARY IMPACT DIMENSION

SYSTEM	ELEMENT	1 Surface Water Quality	2 Surface Water Quantity	3 Ground Water Quality	4 Ground Water Quantity	5 Air Quality	6 Sensory Quality	7 Residential Land Use	8 Commercial & Industrial LU	9 Agricultural Land Use	10 Recreation & Open Space	11 Soil Quality	12 Mineral Resources	13 Energy	14 Access	15 Biotic Communities	16 Unique or Rare Things
1	64 Plant																
2	33 Plant	+	+	+				-									
3	17 Plant																
4	Land	+	+	+			-	-					-	-		-	
5	5 Plant + Land	+	+	+				-					-	-		-	
6	64 Plant CB																
7	33 Plant PC					-											
8	17 Plant AB							-	-				-				
9	Land						-	-	-	-				-		-	-
10	5 Plant + Land							-	-	-				-		-	
11	Ag/CB																
12	Ag/PC													-			
13	Ag/AB													-			
14	Ag/Land																
15	Ag/AB + Land																
16	Land Reclaim													-			
17	Nav -Rec/64																
18	Nav -Rec/33	+									+						
19	Nav /Rec 17	+									+			-			
20	Nav -Rec/Land	+									+			-			
21	Nav -Rec/AB+L	+									+			-			
22	All from L.M.																
23	Pause																
24	Power/6-4																
25	Power/Land													+			
26	Power/AB+L													+			

TABLE FB- 17

INDIVIDUAL A MATRIX

KEHRER: ECONOMIST

(Correlates with Factor 6)

PRIMARY IMPACT DIMENSION

SYSTEM ELEMENT	Surface Water Quality 1	Surface Water Quantity 2	Ground Water Quality 3	Ground Water Quantity 4	Air Quality 5	Sensory Quality 6	Residential Land Use 7	Commercial & Industrial LU 8	Agricultural Land Use 9	Recreation & Open Space 10	Soil Quality 11	Mineral Resources 12	Energy 13	Access 14	Biotic Communities 15	Unique or Rare Things 16
1 64 Plant																
2 33 Plant	+	+				+				+						
3 17 Plant	+	+								+			-	-		
4 Land	+	+			-					+		+	-	-	-	-
5 5 Plant + Land	+	+								+			-	-		
6 64 Plant CB																
7 33 Plant PC					-	-	-					-	-			
8 17 Plant AB												+				
9 Land					+	+	+		+	+	+				-	
10 5 Plant + Land					+	+			+	+						
11 AR/CB																
12 AR/PC																
13 AR/AB											+			+		
14 AR/Land						+								+		
15 AR/AB + Land											+	-		+		
16 Land Reclaim						+				+	+		-			
17 Nav-Rec/64																
18 Nav-Rec/33																
19 Nav Rec 17													-	-		
20 Nav-Rec/Land					-		-	-	-	-		-	-	-		
21 Nav-Rec/AB+L													-	-		
22 All from L.M.																
23 Reuse		+				-							+	+		
24 Power/64																
25 Power/Land		-				+	+						+	-		
26 Power/AB+L							+									

TABLE EB- 18

INDIVIDUAL A MATRIX

EL-NAGGAR: ENVIRONMENTAL ENGINEER

(Correlates with Factor 1)

PRIMARY IMPACT DIMENSION

SYSTEM ELEMENT	1 Surface Water Quality	2 Surface Water Quantity	3 Ground Water Quality	4 Ground Water Quantity	5 Air Quality	6 Sensory Quality	7 Residential Land Use	8 Commercial & Industrial LU	9 Agricultural Land Use	10 Recreation & Open Space	11 Soil Quality	12 Mineral Resources	13 Energy	14 Access	15 Biotic Communities	16 Unique or Rare Things
64 Plant																
33 Plant																
17 Plant																
4 Land													-			
5 5 Plant + Land																
6 64 Plant CB																
7 33 Plant PC	+				-	-						-	-			
8 17 Plant AB	+	+											-			
9 Land	+	+			+		-	-								-
10 5 Plant + Land																
11 Ar/CB																
12 Ar/PC			-													
13 Ar/AB																
14 Ar/Land									+							-
15 Ar/AB + Land																
16 Land Reclaim					+	+							-			
17 Nav -Rec/64																
18 Nav -Rec/33	+	+								+						
19 Nav /Rec 17																
20 Nav -Rec/Land																
21 Nav -Rec/AB+L													-			
22 All from L.M.																
23 Reuse																
24 Power/6-4																
25 Power/Land													+			
26 Power/AB+L					-	-							+			

TABLE EB- 19

INDIVIDUAL A MATRIX

RESHKIN: GEOLOGIST

(Correlates with Factor 3)

PRIMARY IMPACT DIMENSION

SYSTEM ELEMENT	1 Surface Water Quality	2 Surface Water Quantity	3 Ground Water Quality	4 Ground Water Quantity	5 Air Quality	6 Sensory Quality	7 Residential Land Use	8 Commercial & Industrial LU	9 Agricultural Land Use	10 Recreation & Open Space	11 Soil Quality	12 Mineral Resources	13 Energy	14 Access	15 Biotic Communities	16 Unique or Rare Things
1 64 Plant																
2 33 Plant																
3 17 Plant															–	–
4 Land						–	–	+	+	–		+	–	–	–	–
5 5 Plant + Land						–						+	–		–	–
6 64 Plant CB																
7 33 Plant PC						–		+		–		–	–			
8 17 Plant AB	+						+					+				
9 Land			–	–	–	–	–	+		–	–	+	–	–	–	
10 5 Plant + Land							+	+		+		+				
11 Mg/CB																
12 Mg/PC					–	–	–	+		–			–	–		
13 Mg/AB					–	–	–	–	+	–			–	–		
14 Mg/Land					–	–	–	+		–				–		
15 Mg/AB + Land					–	–	–			–				–		
16 Land Reclaim					+	+	+			+	+	+	–	+		
17 Nav -Rec/64																
18 Nav -Rec/33		+				+				+				+		
19 Nav /Rec 17		+				+				+		–	–	+		
20 Nav -Rec/Land		+				+		+					–	+		
21 Nav -Rec/AB+L		+				+							–	+		
22 Fill from L.M.																
23 House				+			+	+				+				
24 Power/6-4																
25 Power/Land	–				–	–	–	+		–		+	+	–	–	
26 Power/AB+L								+				+	+			

TABLE EB- 20

INDIVIDUAL A MATRIX

KREKELER: BIOLOGIST

(Correlates with Factor 3)

PRIMARY IMPACT DIMENSION

SYSTEM ELEMENT	Surface Water Quality 1	Surface Water Quantity 2	Ground Water Quality 3	Ground Water Quantity 4	Air Quality 5	Sensory Quality 6	Residential Land Use 7	Commercial & Industrial LU 8	Agricultural Land Use 9	Recreation & Open Space 10	Soil Quality 11	Mineral Resources 12	Energy 13	Access 14	Biotic Communities 15	Unique or Rare Things 16
1 64 Plant																
2 33 Plant	+	+								+						
3 17 Plant	+	+								+		-				
4 Land	+	+				+				+		-	-			
5 5 Plant + Land	+	+								+		-	-			
6 64 Plant CB																
7 33 Plant PC					-	-						-	-			
8 17 Plant AB						-						-	-			
9 Land									-	-	-		-	-	-	-
10 5 Plant + Land									-	-	-		-	-	-	-
11 Ag/CB																
12 Ag/PC																
13 Ag/AB																
14 Ag/Land																
15 Ag/AB + Land																
16 Land Reclaim						+				+	+		-			
17 Nav-Rec/64																
18 Nav-Rec/33	+															
19 Nav/Rec 17	+											-	-	-	-	-
20 Nav-Rec/Land	+											-	-	-	-	-
21 Nav-Rec/AB+L	+											-	-	-	-	-
22 All from L.M.																
23 Reuse												+	+			
24 Power/6-4																
25 Power/Land	+					+							+	+		
26 Power/AB+L	+					+							+	+		

TABLE EB- 21

INDIVIDUAL A MATRIX

MAIOLO: URBAN SOCIOLOGIST

(Correlates with Factor 4)

PRIMARY IMPACT DIMENSION

SYSTEM ELEMENT	Surface Water Quality 1	Surface Water Quantity 2	Ground Water Quality 3	Ground Water Quantity 4	Air Quality 5	Sensory Quality 6	Residential Land Use 7	Commercial & Industrial LU 8	Agricultural Land Use 9	Recreation & Open Space 10	Soil Quality 11	Mineral Resources 12	Energy 13	Access 14	Biotic Communities 15	Unique or Rare Things 16
1 64 Plant																
2 33 Plant					–											
3 17 Plant													–			
4 Land								–		+	+					
5 5 Plant + Land	+	+														
6 64 Plant CB																
7 33 Plant PC												–				
8 17 Plant AB													–			
9 Land				+				–		+						
10 5 Plant + Land																
11 AB/CB																
12 AB/PC																
13 CB/PC																
14 AB Land																
15 AB/CB + Land										–						
16 Land Reclaim																
17 Nav.Eng/64																
18 Nav.Eng/33										+						
19 Nav.Eng/17																
20 Nav.Eng/Land		+		+		+	+	–		+	+		–		+	
21 Nav.Eng/AB+L		+		+		+	+	–		+	+				+	
22 All from L.M.																
23 Waste										+						
24 Power/64																
25 Power/Land											+	–	+			
26 Power/AB+L													+			

TABLE EE- 22

INDIVIDUAL A MATRIX

CYPRA: WATER RESOURCES PLANNER

(Correlates with Factor 3)

PRIMARY IMPACT DIMENSION

SYSTEM ELEMENT	Surface Water Quality 1	Surface Water Quantity 2	Ground Water Quality 3	Ground Water Quantity 4	Air Quality 5	Sensory Quality 6	Residential Land Use 7	Commercial & Industrial LU 8	Agricultural Land Use 9	Recreation & Open Space 10	Soil Quality 11	Mineral Resources 12	Energy 13	Access 14	Biotic Communities 15	Unique or Rare Things 16
1 64 Plant																
2 33 Plant																
3 17 Plant			–	–												
4 Land			–	–			–	+				+				
5 5 Plant + Land																
6 64 Plant CB																
7 33 Plant PC	+				–	–						–	–			
8 17 Plant AB	+	+		+											+	
9 Land	+	+		+						+			–			
10 5 Plant + Land	+															
11 Ag/CB																
12 Ag/PC							–									
13 Ag/AB									+		+					
14 Ag/Land									+		+					
15 Ag/AB + Land									+		+					
16 Land Reclaim						+				+	+				+	
17 Nav-Rec/64																
18 Nav-Rec/33																
19 Nav/Rec 17													–			
20 Nav-Rec/Land													–			
21 Nav-Rec/AB+L													–			
22 All from L.M.																
23 Pause																
24 Power/6-4																
25 Power/Land	–				–	–		+					+			
26 Power/AB+L																

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